RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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VOLUME LX.

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" 1*a.*—*Productus rewahensis,* sp. nov. Posterior view of same specimen. × 1½.

MGIPC—M—V-2-9—20-7-28—800.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1] 1927. **[April.**

GENERAL REPORT FOR 1926. BY E. H. PASCOE, M.A., SC.D. (Cantab.), D.SC. (Lond.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

DISPOSITION LIST.

DURING the period under report the officers of the Department were employed as follows :—

Superintendents.

DR. L. L. FERMOR . Returned from the field on the 7th February 1926. Granted combined leave for eight months and twenty-seven days with effect from the 19th February 1926. Permitted to attend the International Geological Congress held in Madrid in May 1926. Returned from leave and resumed duty on the 14th November 1926. Placed in charge of office with effect from the 16th November 1926.

DR. G. E. PILGRIM . Returned from leave on the 20th October 1926. Remained at headquarters and acted as Palæontologist since the 1st November 1926.

MR. G. H. TIPPER . Remained in charge of office and acted as Palæontologist till the 8th April 1926. Granted leave on average pay for six months and sixteen days with effect from the 16th April 1926. Returned from leave and resumed duty on the 3rd November 1926. Placed temporarily in charge of the Central Provinces and Central India Party. Left for the field on the 6th December 1926.

DR. G. de P. COTTER . Returned from the field on the 17th April 1926. Left for field work in the Punjab on the 20th October 1926.

DR. J. COGGIN BROWN Continued in charge of the Burma Party.

MR. H. CECIL JONES . Returned from the field on the 15th May 1926. Placed in charge of the Bihar and Orissa Party and left for the field on the 16th November 1926.

Assistant Superintendents.

MR. H. WALKER . . On combined leave.

MR. K. A. K. HALLOWES Retired from service with effect from the 21st April 1926.

DR. A. M. HERON . Returned from the field on the 2nd April 1926. Remained in charge of office till the 15th November 1926 and acted as Palæontologist till the 31st October 1926. Placed in charge of the Rajputana Party and left for the field on the 1st December 1926.

DR. C. S. FOX . . Returned from the field on the 1st July 1926. Left for the field on the 2nd October to examine the coal occurrences in the Salt Range and Bikanir State and returned to headquarters on the 27th October 1926. Placed in charge of the Coalfields Party. Left for the field on the 2nd November 1926 and returned to headquarters on the 9th November 1926. Granted leave on average pay for twenty-two days with effect from the same date. Returned from leave and left for the field on the 1st December 1926.

MR. H. CROOKSHANK . Returned from the field on the 21st April 1926. Detailed for the examination of dam sites for the water supply of Amraoti city. Left for the field on the 28th April 1926 and returned to headquarters on the 7th May 1926. Appointed Curator of the Geological Museum and Laboratory with effect from the 8th September 1926. Attached to the Central Provinces and Central India Party and left for the field on the 27th November 1926.

MR. G. V. HOBSON . Remained at headquarters as Curator of the Geological Museum and Laboratory till the 7th September 1926. Granted combined leave for one year and one month with effect from the 8th September 1926.

MR. E. L. G. CLEGG . Returned from the field on the 9th March 1926. Granted combined leave for eight months and seven days with effect from the 15th March 1926. Returned from leave and resumed duty on the 19th November 1926. Appointed as Curator of the Geological Museum and Laboratory with effect from the 22nd November 1926.

RAO BAHADUR S. SETHU RAMA RAU. Returned from the field on the 26th May 1926. Granted leave on average pay for one month and three days with effect from the 7th September 1926. Returned from leave on the 9th October 1926. Attached to the Coalfields Party and left for the field on the 20th November 1926.

RAO BAHADUR M. VINAYAK RAO. Granted leave on average pay for four months with effect from the 16th April 1926. Returned from leave and resumed duty on the 16th August 1926. Detailed for the continuance of the geological survey of the districts of Salem and North Arcot in the Madras Presidency. Left for the field on the 3rd November 1926.

MR. E. J. BRADSHAW . Returned from field work in Rajputana on the 31st March 1926. Granted leave on average pay for six months and twenty-five days with effect from the 16th April 1926. Returned from leave on the 9th November 1926. Attached to the Burma Party and left for the field on the 16th November 1926.

MR. A. L. COULSON . Granted combined leave for seven months with effect from the 1st April 1926. Returned from leave and resumed duty on the 21st October 1926. Attached to the Rajputana Party and left for the field on the 4th November 1926.

MR. D. N. WADIA . Returned from the field on the 15th May 1926. Granted combined leave for one year, one month and fifteen days with effect from the 6th September 1926.

DR. J. A. DUNN . . Returned from the field on the 12th March 1926. Granted leave on average pay for eight months with effect from the 6th April 1926. Permitted to attend the meeting of the Australasian Association for the advancement of Science held in Perth, Australia, in August 1926. Deputed to investigate the occurrence of aluminous refractory materials in Assam and Bihar and Orissa. Left for the field on the 14th December 1926.

MR. C. T. BARBER . Attached to the Burma Party; remained in Burma throughout the period under report.

MR. E. R. GEE . . Attached to the Coalfields Party and also deputed to make a geological survey of the proposed Kangra Valley Railway alignment, and to report on certain geological aspects of the hydro-electric project at Shanan in Mandi State, to inspect the boring operations for water at the Gun Carriage Factory, Jubbulpore, and to report on the Warcha Salt deposits. Returned from the field on the 22nd October 1926. Left for the field on the 1st November 1926 in connection with the survey of the coalfields of India.

MR. W. D. WEST .	Returned from the field on the August 1926. Detailed for the ex ination of dam sites for the Py Hydro-electric Project and to re on excavations along the dam site the Cauvery-Metur Project. Left the field on the 17th September returned to headquarters on the October 1926. Attached to the tral Provinces and Central India Pa Left for the field on the 16th Nove 1926.
MR. A. K. BANERJEE .	Returned from the field on the 28th 1926. Attached to the Coalfields P and left for the field on the 5th Nov ber 1925.
DR. M. S. KRISHNAN .	Granted leave on average pay for two seven days with effect from the January 1926. Deputed to exa the occurrence of bauxite in Kalah State. Returned from the field the 8th May 1926. Attached to Bihar and Orissa Party and left for field on the 12th November 1926.
MR. P. LEICESTER .	Returned from the field on the April 1926. Attached to the Bu Party. Left for the field on the October 1926.
DR. S. K. CHATTERJEE	Returned from the field on the 1st 1926. Attached to the Rajpu Party. Left for the field on the November 1926.
MR. J. B. AUDEN .	Appointed Assistant Superintend Geological Survey of India; jo the Department on the 16th Noven 1926. Attached to the Coalfi Party. Left for the field on the November 1926.

MR. V. P. SONDHI . Appointed Assistant Superintendent, Geological Survey of India; joined the Department on the 3rd November 1926. Attached to the Burma Party and left for the field on the 12th November 1926.

Chemist.

DR. W. A. K. CHRISTIE At headquarters till the 29th March 1926. Granted combined leave for eight months and twenty-five days with effect from the 30th March 1926.

Artist.

MR. K. F. WATKINSON At headquarters.

Sub-Assistants.

MR. B. B. GUPTA . Returned from field work in Burma on the 14th January 1926. Granted leave on average pay for three months with effect from the 15th January 1926. Attached to the Burma Party and left for the field on the 2nd November 1926.

MR. D. S. BHATTACHARJI Returned to headquarters from field work in the Central Provinces on the 2nd May 1926. Granted leave on average pay for two months with effect from the 19th May 1926. Attached to the Central Provinces and Central India Party. Left for the field on the 8th November 1926.

MR. B. C. GUPTA . Returned to headquarters from field work in Rajputana on the 3rd May 1926. Attached to the Rajputana Party and left for the field on the 6th November 1926.

MR. H. M. LAHIRI . Returned from field work in North-West India on the 14th May 1926. Attached to the Punjab Party and left for the field on the 6th November 1926.

MR. L. A. NARAYANA IYER. Returned to headquarters from field work in Bihar and Orissa on the 18th April 1926. Attached to the Bihar and Orissa Party. Left for the field on the 6th October 1926.

MR. P. N. MUKERJEE . At headquarters.

Assistant Curator.

MR. P. C. ROY . . At headquarters.

The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. Of the three vacancies in the grade of Assistant Superintendent, including the one caused by the retirement on pension of Mr. K. A. K. Hallowes, two were filled during the year, leaving at the end of the year one vacancy.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

Dr. A. M. Heron continued to officiate as Superintendent up to the 19th October 1926 *vice* Dr. G. E. Pilgrim on leave; he was again appointed to officiate as Superintendent from the 20th October to the 13th November 1926 *vice* Dr. L. L. Fermor on leave.

Dr. C. S. Fox was appointed to officiate as Superintendent from the 19th February to the 19th October 1926 *vice* Dr. L. L. Fermor on leave, and again from the 20th October to the 2nd November 1926 *vice* Mr. G. H. Tipper on leave.

Mr. G. V. Hobson acted as Curator, Geological Museum and Laboratory, till the 7th September 1926. Mr. H. Crookshank acted as Curator from the 8th September till the 21st November 1926, when he was relieved by Mr. E. L. G. Clegg.

Mr. G. H. Tipper acted as Palæontologist till the 8th April 1926 when he was relieved by Dr. A. M. Heron. From the 1st November 1926 Dr. G. E. Pilgrim acted as Palæontologist.

Mr. C. T. Barber and Dr. M. S. Krishnan have been confirmed in their appointments as Assistant Superintendents.

The following officers joined the Department during the year :—

Mr. J. B. Auden B.A. (Cantab.) on the 16th November 1926.
Mr. Ved Pall Sondhi, M.Sc. (Punjab) on the 3rd November 1926.

Retirement.

Mr. K. A. K. Hallowes, Assistant Superintendent, retired from the service with effect from the 21st April 1926.

Leave.

Dr. L. L. Fermor was granted combined leave for eight months and twenty-seven days with effect from the 19th February 1926.

Mr. G. H. Tipper was granted leave on average pay for six months and sixteen days with effect from the 16th April 1926.

Dr. C. S. Fox was granted leave on average pay for twenty-two days with effect from the 9th November 1926.

Mr. G. V. Hobson was granted combined leave for one year and one month with effect from the 8th September 1926.

Mr. E. L. G. Clegg was granted combined leave for eight months and seven days with effect from the 15th March 1926.

Rao Bahadur S. Sethu Rama Rau was granted leave on average pay for one month and three days with effect from the 7th September 1926.

Rao Bahadur M. Vinayak Rao was granted leave on average pay for four months with effect from the 16th April 1926.

Mr. E. J. Bradshaw was granted leave on average pay for six months and twenty-five days with effect from the 16th April 1926.

Mr. A. L. Coulson was granted combined leave for seven months with effect from the 1st April 1926.

Mr. D. N. Wadia was granted combined leave for one year one month and fifteen days with effect from the 6th September 1926.

Mr. J. A. Dunn was granted leave on average pay for eight months with effect from the 6th April 1926.

Dr. M. S. Krishnan was granted leave on average pay for twenty-seven days with effect from the 23rd January 1926.

Dr. W. A. K. Christie was granted combined leave for eight months and twenty-five days with effect from the 30th March 1926.

Mr. B. B. Gupta was granted leave on average pay for three months with effect from the 15th January 1926.

Mr. D. S. Bhattacharji was granted leave on average pay for two months with effect from the 19th May 1926.

LECTURESHIP.

Mr. G. V. Hobson continued as Lecturer on Geology at the Presidency College, Calcutta till the 7th September 1926, when he was relieved by Mr. H. Crookshank. The latter was relieved by Mr. E. L. G. Clegg on the 22nd November 1926.

POPULAR LECTURES.

A popular lecture on "The Rise of the Higher Vertebrates" was delivered in the Indian Museum by Mr. P. Leicester during the year.

LIBRARY.

The additions to the Library amounted to 4,961 volumes of which 1,393 were acquired by purchase and 3,568 by presentation and exchange.

PUBLICATIONS.

The following publications were issued during the year under report:—

Records, Vol. LVI, part 4.
Records, Vol. LVIII, part 4.
Records, Vol. LIX, parts 1, 2 and 3.
Memoirs, Vol. XLVI, part 2.
Memoirs, Vol. LI, part 1.
Memoirs, Vol. LII, part 1.
Palæontologia Indica, New Series, Vol. VIII, Memoir No. 4.
Bibliography of Indian Geology, part IV. (Palæontological Index).

MUSEUM AND LABORATORY.

Staff.

Mr. G. V. Hobson was Curator of the Geological Museum and Laboratory from the beginning of the year until September the 7th, when he proceeded on leave. On November the 22nd, on return from leave, Mr. E. L. G. Clegg took over the duties of Curator from Mr. Crookshank who had officiated in the interim. Babu Purna Chandra Roy was Assistant Curator throughout the year, and Babus Austin Manindra Nath Ghose and Dasarathi Gupta fulfilled the duties of Museum Assistants.

Chemist.

Dr. W. A. K. Christie continued as Chemist till the 29th March when he proceeded on leave.

Determinative work.

The number of specimens referred to the Curator for examination and report was 396, of which assays and analyses were made of 53. The corresponding figures for the previous year were 789 and 70 respectively. Chemical work included analyses of coal, coke, limestone, calcareous tufa, oil shale, kaolin, mica-peridotites, laterite, bauxite and basalt.

Donations to Museums, etc.

During the year under review, presentations of geological specimens were made to the following institutions:—

(1) Y. M. C. A. Hostel (Empress Mill Welfare Work), Sitabaldi, Nagpur.
(2) Myoma National Boys' High School, Rangoon.
(3) Australian Museum, Sydney.
(4) Prince of Wales College, Jammu, Kashmir.
(5) Melbourne University.
(6) Spence Training College, Jubbulpore, Central Provinces.
(7) Brahmo Balika Shikshalaya, Upper Circular Road, Calcutta.
(8) The School of Tropical Medicine and Hygiene, Calcutta.
(9) Presidency College, Calcutta.
(10) The Manager, Magnesite Syndicate, Ltd., Salem, Madras.
(11) Geodetic Branch, Survey of India, Dehra Dun.
(12) Indian School of Mines, Dhanbad, Bihar and Orissa.

Included in this collection was a model of an oil drilling derrick which, after exhibition by the Burmah Oil Company at the Wembley Exhibition, had been presented to this Department.

In addition to the above general presentations, the following presentations were made to private scientists :—

(1) Specimens of galena to Mr. B. Brown of the American Museum of Natural History, New York City.
(2) Specimens of stibnite to Mr. J. L. Simonsen, Indian Institute of Science, Bangalore, Mysore.
(3) Portions of the Lakangaon and Nagaria meteorites to Professor Lacroix, Paris.
(4) Specimens of Mogok limestone to Mr. A. E. Cave, Knysna, Cape Province, S. Africa.
(5) Specimens of kodurite rocks and manganese-ores to Professor P. Quensel, Stockholm.
(6) Specimens of mica-peridotite to Professor W. S. Boulton, University of Birmingham.

Specimens received.

In addition to the large number of rock and mineral specimens collected by members of the Department, the following specimens were received and included in our collections :—

(1) A small collection of rocks, minerals and fossils from Mrs. S. Ghosh, Calcutta.
(2) Chabazite, Pennsylvania, United States; by exchange.
(3) Tamarugite, Chile; by exchange.
(4) Teallite, Bolivia; by exchange.
(5) Lapiz lazuli, Badakshan, N. E. Afghanistan. Presented by Messrs. Sadhbans & Co.
(6) Varieties of silica bricks. Presented by the Kumardhubi Engineering Works.
(7) Sarkinite, Sweden; by exchange.
(8) Swedenborgite, Sweden; by exchange.
(9) Ochrolite, Sweden; by exchange.
(10) Hausmannite, Sweden; by exchange.
(11) Braunite, Sweden; by exchange.
(12) Magnetoplumbite, Sweden; by exchange.
(13) Asphaltum, Nepal.
(14) Zinc blende, Kashmir. Presented by Mr. C. S. Middlemiss.
(15) Vredenburgite, Nagpur. Presented by Mr. P. C. Dutt.
(16) Sillimanite brick. Presented by Messrs. Pawle and Brelick, London.

(17) Sulphur, Rawalpindi, Punjab. Presented by Mr. E. S. Pinfold.

(18) Smithsonite, New South Wales; by exchange.

(19) Anglesite on cerrussite, New South Wales; by exchange.

(20) Chabazite, New South Wales; by exchange.

(21) Löllingite, pyrite and cassiterite, Ipoh, Federated Malay States. Presented by Mr. S. E. Wilmot.

(22) Steatite, Jubbulpore district, Central Provinces. Presented by Colonel A. W. Derby, Umaria Colliery.

(23) Ruby and sapphire in matrix, Mogok. Presented by Messrs. the Burma Ruby Mines, Ltd.

(24) Peaty lignite, Kachh. Presented by Mr. J. A. Mitchell.

Meteorites.

During the year fragments of two falls were added to the meteorite collections. Two fragments of a meteoric stone fell on the 2nd May 1926 at Jajh deh Kot-Laloo in Faizaganj *taluk*, Khairpur State, Sind. The total weight amounted to 973·2 grammes. One of these fragments has since been returned and is, it is understood, being sent for exhibition to the Karachi Museum. By the courtesy of the Khairpur Durbar through the Commissioner in Sind the second and larger fragment has been, for the present at any rate, added to the meteorities exhibited in the Calcutta Museum.

Three fragments of a meteoric stone fell on the 26th June 1926 at Dabra (locally known as Dabda) in Nandwai *pargana*, Indore State. Total weight 200·191 grammes.

It is also reported that a meteorite fell at Mouza Lua, Begu *pargana* of the Udaipur State, but no details are yet to hand concerning it.

Burma Laboratory.

During 1926 in the Burma Laboratory 98 specimens were received and reported upon, of which 13 were quantitatively examined. The corresponding figures for 1925 were 42 and 18 respectively.

DRAWING OFFICE.

Mr. K. F. Watkinson remained in charge of the Drawing office throughout the year.

The past year shows a steady increase of work in all sections of the Drawing office. Preparation of plates for publications has been kept well ahead of the requirements of the Press; 115 separate plates were

published during the year, while a large number of illustrations have been prepared for publication in the near future. The amount of map-copying for official reports and departmental use is increasing yearly, but, with the recently increased staff of draftsmen, this work can now be dealt with rapidly and efficiently.

A new edition of the geological map of India on a scale of 32-miles-to-the-inch has been under preparation during the past and previous years. The initial compilation of this map was entrusted to Dr. J. Coggin Brown, whose additions and suggestions have been very carefully reviewed by the Director and the remaining senior officers of the Department. It is intended to print the map in colour in 8 sheets, which will be on sale separately or in complete sets. Several of the sheets are now being fair-copied in the Drawing office, and it is hoped to print off some of them during the coming year.

With regard to the photographic section, 332 negatives were added during the year to the registered collections, which now number 5,841 negatives of all sizes. The number of photographic prints prepared for officers' reports and for reproduction was 1,676—more than double that of the previous year, which amounted to 718.

The number of topographical maps received from the Survey of India during the year amounted to 2,121 against 1,475 maps in 1925. Sixty-eight new geological maps were handed in by officers and stored.

PALÆONTOLOGY.

Mr. G. H. Tipper continued to act as Palæontologist till the afternoon of the 8th April, 1926, when he was relieved by Dr. A. M. Heron. The latter was relieved by Dr. G. E. Pilgrim on the 1st November, 1926. Sub-Assistant P. N. Mukherji has been at headquarters during the whole of the year and has assisted the Palæontologist, not only with routine Museum work, but also with the determination of specimens.

During the year under review, the following Memoir has been published in the *Palæontologia Indica*:—

G. E. Pilgrim: "The Fossil Suidæ of India." Memoir No. 4 of Vol. VIII of the New Series.

Dr. Cowper Reed's memoir on the Upper Carboniferous Faunas of Chitral and the Pamirs, which appeared in January 1925, was inadvertently omitted from the list of memoirs published in the

Palæontologia Indica during the year 1925, as given in the last General Report, though included in the general Bibliography for that year.

The following papers of palæontological interest have appeared in the *Records* :—

(1) "Stegodon Ganesa (Falc. and Cant.) in the Outer Siwaliks of Jammu," by D. N. Wadia.

(2) "On a Collection of Land and Freshwater Fossil Molluscs from the Karewas of Kashmir," by Dr. B. Prashad.

(3) "Description de Quelques Fossiles Crétacés de l'Afghanistan," by H. Douvillé.

(4) "Fossiles recueillés par Hayden dans le Kashmir en 1906 et les Pamirs en 1914; leur description," by H. Douvillé.

(5) "Additions and Corrections to Vredenburg's Classification of the Cypræidæ," by F. A. Schilder.

(6) "The Zonal distribution and description of the larger Foraminifera of the middle and lower Kirthar Series (Middle Eocene) of parts of Western India," by W. L. F. Nuttall.

(7) "Remarks on Carter's Genus Conulites (=Dictyoconoides Nuttall), with descriptions of some new species from the Eocene of North-West India," by Major L. M. Davies.

(8) "Remarks on the known Indian species of Conoclypeus with descriptions of two new species from the Eocene of North-West India," by Major L. M. Davies.

Reference has been made in the last General Report to Dr. Cowper Reed's work on the Palæozoic and Mesozoic fossils collected by Dr. Coggin Brown in Yunnan; to Dr. L. F. Spath's revision of the Jurassic Cephalopods of Kachh; to M. H. Douvillé's descriptions of the collections from the "Cardita beaumonti" beds of Baluchistan and Sind; to the late Mr. Bion's study of the fauna of the Agglomeratic Slate series of Kashmir; to the late Mr. Vredenburg's monograph on the genus *Gisortia* and the same author's "Mollusca of the Post-Eocene Deposits of North-Western India" (*Mem. Geol. Surv. Ind.*, Vol. L, part 2). Memoirs dealing with all these, destined to appear in the *Palæontologia Indica*, are in various stages of progress through the Press, but will in all cases, unless delayed by unforeseen circumstances, be ready for issue before the end of 1927.

In the General Report for 1921 (*Rec. Geol. Surv. Ind.* Vol. LIV, page 14) the occurrence of Productus Limestone fossils at Umaria,

Rewah State, Central India was described. The original specimens, as well as others collected on a subsequent occasion by Mr. Gee, form the subject of a paper by Dr. Cowper Reed, which will appear, accompanied by notes on the stratigraphy by Messrs. Fox and Gee, in a future number of the *Records*. Dr. Cowper Reed's study of the fauna leads him to conclude that while possessing a strong individuality of its own and containing several new and peculiar species, its affinities are closer to Permian than to Carboniferous faunas of other areas.

Professor B. Sahni has completed his revision of the Coniferous section of the Gondwana flora dealing with impressions and incrustations, and this the first instalment of his work has gone to Press, to be issued as a memoir in the *Palæontologia Indica*.

As long ago as 1907, the late M. Cossmann had in his hands for study a collection made by the Geological Survey of India from the Ranikot series. A description of the Cephalopoda and Gastropoda was published in 1909 in the *Palæontologia Indica*, New Series, Vol. 3, pt. 1. A description of the Brachiopoda and Lamellibranchiata accompanied by four plates was completed in 1911. M. Cossmann's manuscript was translated into English and revised by the late Mr. E. Vredenburg, and despatched to M. Cossmann in 1915. It seems never to have reached him. Subsequent to the lamented deaths of both the author and the translator, a duplicate of Mr. Vredenburg's revision and translation, which remained in Calcutta, has been edited by Dr. Cotter, and will shortly appear in the *Palæontologia Indica*.

The material for a still larger memoir on the Mollusca of the Ranikot series was left in the form of notes by the late Mr. Vredenburg. These notes embody the results of a study of D'Archiac and Haime's types of the Nummulitic group of India, now in the British Museum. By comparing these with later collections in India, Mr. Vredenburg was able to separate D'Archiac and Haime's types into their respective stratigraphical horizons, and found that Messrs. Cossmann and Pissarro in their memoirs had referred Ranikot specimens to species of D'Archiac and Haime, which belonged to other horizons. The memoir, which has now been put into shape for the Press by Dr. Cotter, is actually a complete revision of the Ranikot Cephalopod and Gastropod fauna, and includes also descriptions of several new specimens of *Ostræa*; it may be regarded as a supplement to Messrs. Cossmann and Pissarro's memoirs.

The discovery of a fauna of Gault age in collections made by Major L. M. Davies in the Samana range of North-West India was mentioned in the last General Report. As long ago as 1917 Dr. G. de P. Cotter concluded that the fauna of the Giumal Sandstone of Hazara, referred by Mr. Middlemiss to the Cenomanian, was of Gault age, identifying amongst other species its most common fossil as *Douvilleiceras mammillatum* Schlotheim. Dr. Cotter has now embodied his determinations in a short paper, which has been published in the *Records* (vol. LIX, pp. 405-409). In addition he brings forward evidence for the Gault age of fossils from other localities in North-Western India, which have been commonly regarded as Cenomanian.

Mr. Middlemiss' Hazara ammonites have lately been lent for study to Dr. L. F. Spath, who along with other British Museum specialists, is working on Major Davies' Samana collection.

Dr. Cotter has also submitted a paper, partly founded on notes left by the late Mr. Vredenburg, in which the upper Ranikot or even Laki age of the Tibetan fauna ascribed by M. H. Douvillé to the Danian is insisted on. This paper has appeared in volume LIX of the *Records*, pages 410-418.

Dr. G. E. Pilgrim has been continuing his work on the collections from the Eocene Pondaung Sandstones of Burma made by Sub-Assistants H. M. Lahiri and B. B. Gupta. The discovery of an almost complete skull and mandible of *Anthracokeryx*, associated with a radius and ulna, furnishes indisputable evidence of the anthracotheroid nature of the mass of the Artiodactyl fauna as well as of its primitive character. Dr. Pilgrim has also submitted descriptions of several additional Primate remains collected since his paper on the subject in 1915. Amongst these is a maxilla, referred to *Sivapithecus*, which if the reference is correct affords clear evidence of the affinity of that genus to *Palæopithecus*, as the late Mr. Lydekker suspected. These vertebrate fossils will form the subject of two memoirs which, it is hoped, will appear in the *Palæontologia Indica* in the course of this year.

Amongst the collections made by the late Sir Henry Hayden during his last journey across Tibet in 1921, are several specimens of Fusulina Limestone with corals and bryozoa supposed to be of Upper Palæozoic age, and also of Orbitolina Limestone. The former of these have been lately sent for study to Dr. Cowper Reed and the latter to Mr. W. L. F. Nuttall.

Certain rock specimens containing discinoid markings, suspected to be organic and collected from the Vindhyans near Neemuch by Mr. H. C. Jones in 1921, were sent for study to Professor C. D. Walcott and Dr. C. E. Resser, both of the Smithsonian Institute, Washington, and to Professor B. F. Howell. A reply from Dr. Ressee indicates a general consensus of opinion that the markings represent true fossils and definitely brachiopods, which agree most closely with forms of *Acrothele* from the Cambrian.

Some months ago Mr. S. M. Mehta, Director of Mines and Geology for the Gwalior State, sent to this office a partially worn boulder of a fine grained semi-crystalline limestone, supposed to have been found at Kailaras hill, on the site where the Vindhyan Bhander Limestone is quarried by the Gwalior Cement Company. This boulder had been split and the fracture revealed a well preserved shell, only partially exposed. This was determined by Dr. Cotter as a lamellibranch, possibly inoceramoid, but in any case bearing more resemblance to Mesozoic than to Palæozoic types. In view of the two possibilities, (1) that definite evidence for the occurrence of fossils in the Vindhyans might at last be forthcoming; or (2) that an unsuspected inlier of later age might be found in the Vindhyans, both of great interest, Mr. Tipper was deputed to examine the locality. Unfortunately he could find no trace of a fossil anywhere near the locality; he was, moreover, unable to parallel the boulder exactly with any band of rock which was being quarried, although its appearance corresponds, as Dr. Heron noticed, with that of the Lower Bhander Limestone in general. Thus the occurrence lacks confirmation and fossils in the Vindhyans must still be regarded as non-proven.

Amongst the numerous fossil specimens submitted to the department for determination during the year, was a lower jaw of *Tetraconodon minor*, Pilg., collected by Mr. A. E. Day of the Indo-Burma Petroleum Co., from the base of the Irrawaddy series at Yenangyaung. The jaw contains the root of the canine, up till now unknown in this genus; its scrofic cross-section, different from that of other contemporary Indian pigs, accords with that of the European *Conohyus simorrensis*, which Stehlin and Pilgrim have shown to be near the ancestral line of *Tetraconodon*. Dr. Pilgrim is writing a short note on the specimen.

A fine series of Proboscidean teeth was collected by Mr. A. E. Day from the base of the Irrawaddy series at Taungbyinge in the Lower Chindwin district of Burma. Dr. G. E. Pilgrim, who has examined

them, is of the opinion that they represent an altogether new Proboscidean facies. There is not a single species among them which can definitely be assigned to any hitherto known Indian form. A first lower molar agrees closely with a specimen from Sind figured and described by Lydekker under the name of *Mastodon falconeri*. Several teeth are undoubtedly allied to *Mastodon angustidens* var. *palæindicus*, by their narrowness, broad cingulum and general arrangement of cusps, but the much more complicated talon of m_3 indicates that they represent a much more advanced stage. Another form shows affinities to *Mastodon pandionis*. Another may be an ancestral form of *Prostegodon latidens*; this is the newest looking form of them all. Yet another by its simple cusps reminds one of *Hemimastodon crepusculi* more than anything else; it is a fragmentary tooth but obviously contains a greater number of ridges than the Baluchistan species. The absence of all the usual Middle Siwalik forms indicates that the horizon must be placed somewhere in the Chinji zone. In the collection there are also a last lower molar of *Listriodon pentapotamiæ* and a jaw of a large pig with P_4—probably a small species of *Sivachærus*—which are supposed to have come from the same beds. These do not conflict with the idea that they are of Chinji age. This is an interesting and important conclusion, and accords well with the opinion which Dr. Cotter has expressed that marine are replaced by fluviatile conditions as one proceeds from south to north. This point was emphasized by Dr. Pilgrim in the case of the Irrawadian series in a paper contributed to the Pan-Pacific Congress for 1923.

The typical Dhok Pathan facies of the Siwaliks is shown in another collection of Proboscidea made by Mr. C. T. Barber in the neighbourhood of Mount Popa in the Myingyan district. This contains forms of Prostegodon allied to *Prostegodon latidens* and *P. stegodontoides*.

A considerable number of fragmentary fossils obtained from a boring in the Khairpur State, Sind, were submitted to the department for determination. While the newer beds yielded evidence of Tertiary strata, the lower beds suggested the presence of Triassic rocks, by the occurrence of an ammonite referable to the family of the *Arcestidæ* and a possible orthoceratoid cephalopod.

In the course of a tour in the Karakoram range Captain K. Mason of the Survey of India obtained some fossils which were sent for determination. Mr. Tipper, who examined them concluded that most

of them were assignable to the *Perisphinctes* group of ammonites, and were probably of the same age as the Spiti Shales.

A small collection of European fossils was kindly presented to the department by Mrs. Mon Mohun Ghosh of Calcutta.

Surveyor Chiragh Shah of Air Survey Party No. 18 of the Survey of India, while at work in the Pusht-i-kuh Range in Persia, found several well preserved fossils of Cretaceous age. He has presented specimens of the following species to this department:—*Ostræa* (*Lopha*) *dichotoma* Bayle, var. *persica* Douvillé; *Spondylus subserratus* Douvillé; *Iraniaster morgani* Cotteau and Gauthier; *Iraniaster douvillei* Cotteau and Gauthier; *Hemiaster iranicus* Cotteau and Gauthier; *Pyrina orientalis* Cotteau and Gauthier.

During the year presentations of fossils were made to the following institutions:—to the British Museum (Natural History) a collection of duplicate ammonites of the Himalayan Trias: miscellaneous collections to Melbourne University; to the Prince of Wales' College, Jammu; to the Department of Botany, St. John's College, Agra; to the Director, Geodetic branch, Survey of India Training School, Dehra Dun; to the Central College, Bangalore, Mysore; to the Oriental Seminary, Calcutta; to the Kotgarh School, Simla Hills; to the Y. M. C. A., Nagpur, Central Provinces.

In addition to the facilities afforded to geologists of the various oil companies and to others to work out their collections of fossils with the help of our library and museum, fossils have been in some cases lent to such geologists for comparison during their work in the field.

PETROLOGY.

Mr. West draws attention to an interesting point that arises from a consideration of the mode of occurrence of the calc-granulites of the Central Provinces, although it has no direct connection with the geology of the Central Provinces. Professor Daly has advanced a well-known hypothesis in accordance with which he attributes the formation of nepheline-syenites and other alkaline rocks to the solution of limestones in acid granitic magmas. It is supposed that if a granite magma dissolves calcium and magnesian carbonates, the lime and magnesia will enter into combination with the free silica; and it is also supposed that these oxides will desilicate the higher silicates *e.g.*, by taking silica from the albite molecules to produce nepheline. Differentiation is then supposed to take place

yielding one fraction rich in lime and magnesia and the other rich in alkalies but with a shortage of silica so that ortho-silicates, such as nepheline, crystallise out. According to the views now held on the origin of the calc-granulites of the Central Provinces, we appear to have had here the most favourable conditions for this reaction of Daly's to take place. In order to account for a great number of observed facts it has been supposed that the calc-granulites are composite rocks which have been produced by the immediate penetration of a calcareous sediment by thin sheets of acid magma. Assuming this to be correct, it is clear that, if Daly's hypothetical re-action had taken place, one would find that the lime had been absorbed to such an extent that not only would there be no free silica left, but the higher silicates, such as albite and orthoclase molecules, would have been desilicated to give such lower silicates as nepheline. This, however, has not happened. Reaction between silica and lime seems to have been relatively restricated, and it is quite clear that the reaction pictured by Daly has not taken place, in spite of the very favourable conditions.

Simla Hill States.

The results of Dr. G. E. Pilgrim's and Mr. W. D. West's work in the hills between Simla and Chakrata during the spring of 1925 were referred to in the last General Report. These appeared to be of such importance that it was considered advisable to continue geological work in the same area. Dr. Pilgrim was unable to take part in this owing to his absence on leave, but Mr. West was instructed to examine in greater detail a portion of the country which had been traversed in the previous season. Mr. West's work in 1926 has confirmed the main conclusions previously reached, but has at the same time extended and in part modified them. Dr. Pilgrim had affirmed the existence of two distinct series of rocks, both older than the Simla Slates and the Blaini, and both brought into their present position by faulting :—(1) the highly metamorphosed and carbonaceous quartzites, schists and limestone of Simla and Jutogh ; (2) a series of quartzites, schists and conglomerates correlated with Oldham's Jaunsar series and comprising most

of the rocks exposed on the Simla motor road between Katli Ghat and Kiari Ghat. Mr. West's detailed mapping has shown that there is yet a third series intermediate in age between the other two and also overthrust, to which he has given the name of the Chail series, the existence of which Dr. Pilgrim had not suspected. This contains quartzites, quartz-schists and phyllites. Its most conspicuous and most constant member is a band of talc-schist of a silvery colour never more than 30 or 40 feet thick; it is near the base of the series and has been the chief factor in disclosing the individuality of the Chail series and its faulted relations to the Jaunsars. Mr. West has found that, both in the case of the Blaini as well as of the Jaunsar and the Chail series, bed after bed is in each case gradually cut out against the boundary which separates it from the overlying but actually older series. This conforms with the supposition that the boundary in question is the trace of a thrust plane.

Mr. West claims that one of the recumbent folds in the Jutogh series can actually be seen to close in the neighbourhood of Sanyon Didag, situated south-west of the Chor Peak, thus confirming their nature and affording strong evidence for Dr. Pilgrim's opinion that the metamorphosed rocks at Simla and Jutogh represent portions of two such recumbent folds. Mr. West regards the recumbent folding as approximately contemporaneous with the regional metamorphism and with the intrusion of the Chor granite and prior to the deposition of the Chail and Jaunsar series, while the thrust-faulting is obviously newer than the deposition of the Krol and may possibly be Tertiary.

Mr. West has not found these three older series in their natural order of deposition; this is evidently due to the thrusts being so long and intense that their "roots" have not been reached. Dr. Pilgrim, however, considers that he has found natural sections along the western bank of the Tons and seven miles S.E. of Chakrata, in which the Jutogh series unconformably underlies the Jaunsars.

It is proposed that the work shall be resumed this spring, and that after an inspection of Mr. West's last season's work by Dr. Pilgrim, the two should work separately and converge on Simla from different directions.

There is no doubt that the discoveries of Dr. Pilgrim and Mr. West explain many of the anomalies of the area. Their interpretation explains the following points :—

(i) the similarity of the Jacko and Jutogh carbonaceous slates ;

(ii) the markedly younger appearance of the rocks in the direction of Mashobra or Wild Flower Hall—*i.e.* to the N. E.—as compared with those in Simla itself in spite of the general south-westerly dip ;

(iii) the composition of the boulders in the two Boulder Beds, many of which consist of a comparatively coarse micaceous sandstone—a type of rock found close to and on the Mashobra side (N.E.) of the Boulder Beds, but not on the Simla side (S.W.).

Followed N.W. of Chadwick, the writer found the Blaini Limestone and Upper Boulder Bed disappearing just beyond the village of Nerabal. The Bleached Slates were traced for two or three miles further in a N. W. direction, and were found to be thinning out.

Down the spur N.N.E. of Chharabra, just east of "△6651," was found an impure limestone much resembling the Blaini Limestone, flanked on the west by slates identical with the Bleached Slates; the junction was obscured, and the presence or absence of a Boulder Bed not determined. A similar limestone was observed near Jandot two or three miles N.N.E. of Phagu. Bleached slates are also conspicuous in this neighbourhood and carbonaceous material present. There seems little doubt that some of the Simla rocks are, therefore, repeated in this region. The Mahasu ridge and its continuation eastwards past Phagu consists of a quartzite similar to the Boileaugunge Quartzite. Massive quartzite is again met with further along the road to Mattiana from "△8317" to "△8473."

Seychelles Islands.

During the year the Government of the Seychelles took the opportunity of enlisting, with the consent of the Government of India, the services of Dr. Christie on his way to South Africa on leave. The classical occurrences of bauxite on these islands seemed worth further geological investigation

and Dr. Christie has submitted a preliminary report thereon, the result of four weeks on the islands in April and May. The result has been disappointing, since, after an exploration of most of the occurrences on the principal island, Mahé, and a cursory examination of the islands, Frigate, Félicité, La Digue, Curieuse, Praslin, Silhouette, Long and Cerf, he was unable to find any workable deposit of bauxite.

By far the greater part of the unaltered rocks of the Seychelles is granitic in character with a large percentage of quartz. The latter feature is adverse to the production of bauxite, and the absence of tablelands to the formation of laterite. The rocks weather either into conical hills, or more frequently into ridges with sharp backs, so that, as Dr. Christie remarks, laterite has a poor chance of forming as a capping to the granite, and the tops of the hills and ridges are usually formed of the original rock.

The climate with its equably distributed rainfall of 100 inches a year, is also against the accumulation of laterite or bauxite.

Dr. Christie, however, reports large accumulations of secondary or detrital laterite, which have been protected from complete denudation by vegetation. There are many good exposures of detrital laterite on Mahé, generally in road cuttings and in clearings for houses, sometimes as the result of landslips. It occurs as an earthy to friable mass, generally reddish brown in colour but often with a purple tinge. In any big accumulation of this detrital material quartz grains form a disappointingly large percentage and the redness of its colouring generally indicates a higher iron content than would be desirable in an ore of aluminium. Frequently there are patches where the laterite has been locally concentrated, with the elimination of quartz, by the varying speed of the water carrying the materials, and sometimes such patches are pale in colour, but close at hand quartz grains will be found in profusion. In Dr. Christie's opinion they could not be separated by sieving, and a washing process, on the lines, for instance, of that in vogue at the Cornish China clay deposits, would be too expensive even if the resulting aluminium ore contained less iron than the concentrate would contain. The rocks seen on Silhouette contain less quartz than those of the other

islands; they are syenites as distinct from granites and are rich in a black hornblende, which gives a deep brown colour to the decomposed rock. The laterite or more commonly lateritic clay, formed from these rocks on Silhouette, is detrital and, although quartz grains are uncommon, the material is highly ferruginous.

International Geological Congress.

In response to an invitation from the Government of Spain, it was arranged that Dr. L. L. Fermor, who was on leave in England during the summer, should attend, as the representative of the Geological Survey of India, the 14th International Geological Congress, which was held at Madrid in May. In conjunction with these Congresses, excursions are arranged prior to and in continuation of the Congress meeting to places of special geological interest in the country in which the Congress is held. Before the meeting in Madrid, Dr. Fermor took part in an expedition to the Canary Islands, in order to study the volcanic rocks of that region. Three islands were visited—Tenerife, Las Palma and Gran Canaria—and in Tenerife an ascent was made of the famous volcanic peak of Teyde (3710 metres or 12,180 feet), usually known as the Peak of Tenerife. Numerous interesting specimens of volcanic rocks (basalts, andesites, trachytes and phonolites) were collected for comparison with Indian types but, unfortunately, the collection was destroyed by a fire at sea on S. S. *Fontainebleau*, the vessel on which the collection was shipped to India. After the Congress, Dr. Fermor joined excursions to the Asturias and Bilbao regions in northern Spain, visiting mines of coal, manganese-ore and iron-ore, and making a small collection of specimens, which has reached Calcutta safely.

ECONOMIC ENQUIRIES.

Bauxite.

Kalahandi State: Bihar and Orissa.

Some analyses of bauxite obtained from Korlapat Hill, Kalahandi State, having shewn a percentage of alumina of over 67, Dr. Krishnan was deputed to visit the hill. A short paper embodying the results of his investigations has

already appeared in the Records of the Department (vol. LIX, pages 419-422). Samples yielding 61·92 per cent. of alumina were obtained but the extent of the deposit is doubtful.

Building Materials.

(*See also* LIMESTONE AND MARBLE.)

Sandstone, Pokokku district : Burma.

Mr. Barber reports that at Tangu (95° 3′: 21° 42′), in the Pakokku district, the Pegu sandstone is so even-textured and so regularly joined as to form a workable freestone; it is extensively quarried by the local inhabitants. It is used chiefly for the construction of pagodas and carved into fantastic images for their decoration. It is also used for coping-stones, cattle troughs and flooring purposes and the prepared stone is widely exported.

Limestone, Lower Chindwin district : Burma.

At Maukthayet (94° 58′; 22° 7′), in the Lower Chindwin district, Upper Burma, the limestone which occurs as reefs in the Pegu clays is extracted and burnt for lime on an extensive scale and forms one of the principal occupations of the villagers in this area. Mr. Barber remarks that, owing to the lenticular nature of the limestone reefs, extraction is a laborious process and many hundredweights of useless rubbly clay have to be excavated to obtain one hundredweight of limestone sufficiently pure for burning. After firing it yields a pure lime which, when slaked, makes a good mortar. After repeated slaking, the lime is also used for consumption with the areca nut. In former times, Maukthayet lime found a ready market over a wide area in Upper Burma, but the industry has suffered considerably from the competition of the Sagaing lime, and its sale is now restricted to the western parts of the Lower Chindwin district.

Cement Materials.

Erode, Madras.

The country around Metur and to the south near Sankaridrug was explored by Mr. Vinayak Rao in a search for limestone required for the manufacture of cement for the Cauvery-Metur Dam Project in Erode, Madras. *Kankar* of very good quality is found on the left bank of the Cauvery, but the quantity is insufficient, and the material would have to be collected from different places. The existence of

limestone bands near Sankaridrug is mentioned in Le Fanu's Manual of the Salem district, and Mr. Middlemiss of the Geological Survey of India had noticed two bands between Sankaridrug and Bhavani.

The limestone, or rather marble, occurs as thin bands extending for miles with an irregular width. It was found at a depth of 40 feet in well sections, and apparently extends further down. It is associated with the newer granites of the Sankaridrug hill and adjoining hillocks which have intruded the older peninsular gneisses. It is of the same age as the Krishnagiri and Jalarpet granites. It seems to cut across a saddle of a hill north of Sankaridrug and extends as thin veins along the side of the hills and across the valleys. There are broad patches of the limestone—possibly of secondary origin—on the slopes of hills.

The marble or limestone is of good quality. The following is the result of an analysis in the laboratory of the Geological Survey of India :—

SiO_2	7·26
Fe_2O_3 & Al_2O_3	1·87
CaO	49·84
MgO	1·04
Loss by ignition	38·61
	98·62

Sankaridrug marble is therefore very suitable for the manufacture of cement. It is found close to the main road and railway line, and could be easily carted or trammed to Metur. The cement could, in Mr. Vinayak Rao's opinion, be manufactured on the spot and then sent on to the works.

Copper.

Lower Chindwin district : Burma.

The copper ores malachite and chalcanthite were found by Mr. C. T. Barber to occur locally as vein minerals in the rhyolitic agglomerates and tuffs of the Letpandaung Hills (Survey sheet 84 $\frac{N}{4}$), of the Lower Chindwin district, Upper Burma, but the extensive workings which had been opened here by Messrs. Jamal Brothers to extract these ores have now been abandoned. No statistics of the amount of ore extracted from this area are available. Dr. J. Coggin-Brown, who accompanied Mr. Barber when these deposits were

examined, is of the opinion that the proportion of ore is too small for profitable exploitation.

The exact nature of the processes by which these ores were deposited has yet to be elucidated by a systematic examination of slides prepared from the specimens collected at this locality, but the tuffs and agglomerates in which they occur appear to have undergone considerable hydrothermal or metasomatic alteration, and it is probable that the introduction of the ores is intimately connected with these phenomena.

Mewar : Rajputana.

The junction of the Delhis and the Aravallis, *i.e.*, the eastern foot of the first ridge which faces the central plain of Mewar, has been noticed by Dr. Heron as in many places characterised by copper-staining. It never reaches economic possibilities, but numerous prospecting pits have in the past been put down at intervals along the line of impregnation. The green-stained quartzite is offered for sale to tourists at Udaipur and Jaipur as "jade".

Engineering and Allied Questions.

Thinbon Tank Project, Meiktila district: Burma.

At the request of the Government of Burma, Dr. J.Coggin Brown visited the Meiktila district in February and reported on the geological aspects of the Thinbon Tank Irrigation Project, with special reference to the permeability of the proposed reservoir and the suitability of the dam site.

The site lies 3 miles south-south-west of Kyaunggon, a village 14 miles to the north of Meiktila town. The location is in the "dry zone" of Upper Burma and some provision has already been made to distribute the water supply of the Thinbon Chaung by means of the Inyein weir and canal system. The weir is about 3 miles down stream from the proposed dam site. The Thinbon Chaung is subject to very sudden spates of great volume and short duration. One or two of these usually occur in early June when a small portion of the water is drawn off by the canal for starting "paddy" nurseries. The greater part of the supply runs to waste over the weir. The next freshets occur, as a rule, in late August or the beginning of September, and during the intervening dry period the feeds suffer, resulting in a scarcity of plants. By the end of October, in almost every year, there is a shortage of water for maturing the crops and

a large acreage has to be classified as a failure. The proposed reservoir had a capacity large enough to damp out the floods, and to store the water from the early spates so as to maintain the nurseries and mature the crops later in the season. The present canal system irrigates 3,400 acres out of a commanded area of 40,000 acres. By the construction of the reservoir an additional 7,800 acres were to be irrigated. A masonry dam with a core of boulders in concrete was to be built across a narrow part of the *chaung* where it has breached a low range of hills. The length of the dam was to be 170 feet at stream level and 810 feet at the top; the maximum height was to be 59 feet in the centre of the stream. The area submerged at high flood level was estimated at 1,010 acres and the storage capacity 486 million cubic feet. The average annual rainfall for a period of 11 years at the nearest recording stations was 31·85 inches.

A detailed geological examination was made and the reservoir area found to lie entirely in rocks of Pegu age, on the western slopes of an asymmetric anticline composed of rapidly alternating beds of sandstone and shale of very variable composition, dipping generally at low angles to the west and south-west. Overlying these, especially near the streams, are sandy alluvial deposits. The latter are permeable and will absorb water. The porosity of the sandstones varies greatly, from the soft, open-textured and pervious kinds, to the harder and more compact sorts which are impervious enough for all practical purposes when unbroken. The exposures of the latter displayed an unusual amount of jointing and cracking, all of which would provide avenues for the escape of water at first. On the other hand, in the silty and clayey shales which are interbedded with the sandstones, there are impermeable layers which will hold up any water reaching them. They too contain cracks and master-joints at the surface. At least two faults are known to cross the basin and there are undoubtedly others hidden by the alluvial blanket, but it was anticipated that the fault planes would be partially sealed by the pugged clay of the broken zones, which they themselves have caused.

Dr. Coggin Brown has reported that he did not expect such a reservoir site would ever be quite water tight. For some time after its inception, there would be much leakage and loss from percolation, perhaps sufficient to render it useless for the first few seasons. He believes, however, that this would remedy itself with time;

the water channels would ultimately be staunched by clayey silts, so that, eventually there is no reason to suppose that the leakage from the proposed reservoir would be worse than that from areas of water impounded on similar strata elsewhere in the district, the absorption factors of which are doubtless known to the irrigation authorities.

The dam site is situated on the easterly and more steeply dipping limb of an asymmetric anticlinal fold, the rocks of which dip down-stream at about 30°. It is not an ideal location. The line of the dam, moreover, is oblique to the strike of the rocks, which is unfortunate in such variable strata, for the foundations cannot be laid on the best local bed obtainable right across the valley; they must cross several members of an unusually unreliable group of rocks, the bedding planes of which might constitute channels for water percolation under the dam. Worse defects still are, firstly, the lateral changes in the composition of the rocks themselves within short distances and, secondly, the fracturing and shattering which they have undergone. Dr. Coggin Brown found it impossible to give a final verdict, until the whole of the site was explored by means of a deep trench going through the upper decomposed layers, well down into the unaltered rock, when the ramifications of the joint planes, cracks, etc., all of which could provide channels for the percolation of water under pressure, might be traced and the feasibility, economic and otherwise, of sealing them up with cement grouting considered. He expressed the opinion that the cracking had been intense enough to make it doubtful whether such a preliminary expenditure were justifiable, as it might be found impossible to render such a floor water-tight without prohibitive cost. He suggested that the site and its surroundings might be studied by the engineers with a view to the construction of a well drained earthen dam, several of which, though obviously slightly leaky, successfully impound water on Pegu rocks in the neighbourhood.

Stains on Building Stones in the Imperial Secretariat, Delhi.

In January Dr. Cotter was deputed to examine certain dark stains which had developed on some of the cut stones in the new Imperial Secretariat building in Delhi. An examination by the Curator in the Geological Survey Laboratory showed that the black colour was due to carbonaceous deposit. Dr. Cotter was of opinion that this deposit was largely due to the oozing out of moisture from

the mortar, and considered that the process would cease after the building had thoroughly dried. The recommendation made was periodical cleaning with hot water and a scrubbing brush, followed, after the building had thoroughly dried, by a final clean up with a blow lamp, burning methylated spirit; the flame should be played upon the damped stone. It is hoped that the superheated steam thus formed will combine with the carbon and carry it away as water gas.

Pykara dam, Ootacamund : Madras.

Mr. W. D. West was deputed to examine some proposed sites for a dam on the Pykara River in the Nilgiri Hills, some 12 miles from Ootacamund. The dam forms part of a scheme for the generation of electricity, and is required to shut off a reservoir in the valley with a capacity of over 3,800 million cubit feet. The rocks belong to the Charnockite series and when fresh would form a sound base, in spite of rather conspicuous jointing. Owing partly to the immense age of this old land surface the rocks have unfortunately become disintegrated to great depths, the underground circulation of water having been facilitated by the jointing. Chemical products from the thick covering of grass and other vegetation have no doubt contributed towards the decomposition of the rocks. Remnants of undecomposed rock have been left in the midst of the kaolin and other soft products, and these *quasi*-boulders when encountered by the drill are apt to give the impression that country rock has been reached.

Above the road bridge good solid rock *in situ* is seen on the left bank, but on the right bank it is doubtful whether reliable foundations are obtainable either at a suitable depth or at a convenient distance into the hill-side. Below the bridge there are excellent foundations on the right bank and in the river, but the suitability of the left bank is at present uncertain and requires further investigation by excavation. Should these investigations prove favourable the site below the bridge is regarded as the most suitable.

Cauvery-Metur Dam Project, Erode: Madras.

While investigating the Pykara dam site near Ootacamund Mr. West was asked to inspect some excavations which had been made along part of the dam site for the Cauvery-Metur Project since Dr. Smeeth reported on the site. Mr. West's conclusions were that, in the

saddle on the right side of the site, which is to be used for the discharge of surplus water, sound, solid rock should be found nearly everywhere at a depth of a few feet below the surface. The rock across this saddle varies considerably, and includes some rather soft micaceous gneiss, somewhat deeply weathered in places, and some acid (siliceous) gneiss, which might give trouble if not properly dealt with. The greater part, however, seems to be quite sound.

In considering the suitability of this saddle as a site for the discharge of surplus water, the point to be considered is whether the scouring action of the water will have much effect on the underlying rocks. As regards the greater part of the saddle in Mr. West's opinion there should be no cause for any anxiety, provided the downstream side of the saddle be suitably terraced, so that the drop of water is never more than 10 feet. Further excavation will show if the weaker varieties of rock mentioned above are at all prominent or remain as weak in depth. It is thought that any difficulty of this sort could be overcome by using masonry at these points to join up the zones of sound rock which probably occur over the greater part of the saddle at a small depth.

As this site will only be used occasionally for the discharge of water (the main discharge going over the saddle to the left of the dam), any scouring action which might begin could be repaired in its early stages during the long periods when the site is not in use.

The rock is almost white in colour. It is not certain whether it represents a siliceous variety of the gneiss or is mainly pegmatitic material. In either case there is no reason to suppose that it does not continue in depth.

A boring was put down in the midst of this section to 69 feet below the surface of the ground. The core obtained consisted of rather small pieces of the above mentioned rock. This rock in itself seems to be quite sound; but it appears that during the boring numerous sections of a very soft rock were encountered, so soft that no cores of it were obtained, the drill suddenly descending several inches as each patch was reached. It is not quite clear to what this was due; and it has, therefore, been suggested that either the boring be continued to see whether the rock as a whole becomes sounder, or that further excavation be made in this trench.

Unfortunately, the foliation of the rocks throughout this part of the dam site, and no doubt throughout the whole site, is parallel to the length of the valley, *i.e.* at right-angles to the length of the dam. It

is therefore essential that perfectly sound foundations be secured throughout the whole length of the site. Should a certain section be less sound, any leakage that takes place, however slight at first, will be facilitated by the foliation of the rock, which in the more micaceous varieties is strongly marked. Under a high pressure of water this might increase rapidly, and so undermine the foundations.

The remainder of this long pit shows badly weathered micaceous gneiss or schist in the more superficial portions, but the stability of the rock seems to be improving rapidly in depth.

The other cores examined were all of perfectly fresh sound rock. The pits further to the right showed fresh charnockite quite close to the surface of the ground; it all appeared to be quite sound. Dr. Smeeth in his report considered that this site was the best available. Mr. West notes that as the strike of the rocks is parallel to the length of the valley, any other sites are likely to have the same zones of softer rock, and they may be more prominently developed. In addition, this site has the great advantage of suitable saddles for the discharge of the surplus water.

Landslips, Nilgiri Railway, Madras.

Rao Bahadur Vinayak Rao was entrusted with the investigation of some small landslides in the hill section of the Madras-Ootacamund Railway with a view to decide whether more serious slides were threatening.

The valley along which the railway line runs from Kallar to Coonoor is that of the Coonoor river which joins the Bhavani west of Mettupalaiyam in the plains. This valley has an approximate east and west direction. Above Runnymede station (4,620 feet) the Coonoor river is joined by other streams and the head of the valley below Coonoor has a rough horse-shoe shape with gently sloping slides. Below Runnymede the valley narrows, the hill-sides are precipitous and there is a fall in the river-bed of some 3,000 feet in the course of about 3 miles. On either side of the valley the hills rise to a height of nearly 7,000 feet.

The rocks of this area consist mostly of acid garnetiferous charnockite with bands of basic and intermediate varieties. The charnockite has a foliation E.N.E.—W.S.W. which sometimes becomes N.E.—S.W.; the former is the prevalent direction. There are three sets of joints. One about 10° W. of N. to 10° E. of S., is well developed and shows as large cracks on the hill-side. The second is almost at right angles to the first and forms a horizontal

joint, sometimes making an angle of 70° with the first, when it gives the rocks an appearance of false-bedding. The third set is parallel to the foliation. These three sets of joints combine to break the charnockite into rectangular blocks. On a hill-slope the lowest of these rectangular blocks falls first; the one above it, left hanging in mid-air, is the next to drop, and so on. At the head of the valley and on some of the hill-slopes the rocks weather in a concentric manner.

One of the features of weathering is the occurrence of solid cores of rock in a highly weathered hill-side of soft material. It is this peculiarity which is responsible for at least two of the biggest slips on the railway, *viz.* those at miles 10-1 and 14-11.

Between Runnymede station 11°19′ : 76° 46′) and Coonoor there are four streams joining the Coonoor river and its tributary. The hill-slopes close to these streams are highly weathered. Below Coonoor the rocks in the railway cuttings are so weathered that a dyke intruding into the charnockites has, where exposed, been completely transformed into clay.

About 1½ miles below Coonoor and just above Karteri Road station at the toll-bar on the Mettupalaiyam-Ootacamund road (mile 19-2) a subsidence had taken place during the recent Rains. Vertical cracks were observed on either side of the road which has a bend here. The block, which has been let down to a depth of about 1 foot 8 inches, has a width of about 178 feet narrowing to 128 feet just below the road. The vertical cracks extend up the hill-side to the north to a height of about 100 feet; here the subsidence is about 4 feet. The cracks extend in a north and south direction—the direction of the principal joint in the charnockite. The subsidence was attributed by Mr. Vinayak Rao to the cuttings for the cart road and railway line immediately below it, to the water-courses on either side and to the irrigation in the tea-garden close by. Immediately below this slip is a railway tunnel which is fortunately protected by stone-casing. There is also solid rock close to the tunnel on one side, and Mr. Vinayak Rao considered that there was no danger to this tunnel for the present.

There is little doubt that the disintegrated soil in this area, supporting large blocks of undecomposed rock, will be liable to slips from time to time. As a preventive measure stone retaining walls are suggested wherever there is soil or decomposed rock or loose blocks along the railway line. The reported movement of the

hill-side seems to have been merely the movement of boulders by rain in the soft earth. The average rainfall in this area is about 82·25 inches.

The large mass of rock known as Lamb's Rock (11° 21′ 30″ : 76° 50′) due north of Hillgrove station has precipitous sides. The debris from the cliff has covered the slopes of the hill and large boulders sometimes tumble down the hillside. This area must be carefully watched. Neither this rock mass nor the precipitous rock overhanging the railway line between miles 11-5 and 11-8 show any sign of having moved. The accidents on the line are due to loose boulders crashing down from the top. A watch should be kept over these areas—especially between Hillgrove and Runnymede. If stone retaining walls are put in hand at once over the weak places along the railway line between Adderley and Coonoor and attention paid to dangerously situated blocks of rock in the cuttings here as well as the ones below Adderley there is probably little to fear. Mr. Rao thinks that delay might result in bad slips during the next Rains. Some of the rock in tunnels Nos 6 and 7 was thought to be in an unstable condition.

Kangra Valley Railway, Punjab.

During the month of May 1926 Mr. Gee was deputed to carry out a geological inspection of the proposed Kangra Valley Railway alignment. It is intended to continue communications from Pathankot, (R. L. 1,088 feet), *viâ* Kangra, Palampur, and Baijnath, to the site of the Punjab Hydro-Electric Project at Shanan, (R. L. 4,250 feet), in Mandi State. This extension will be about 103 miles long, and of the narrow 2½-foot gauge.

The main boundary fault of the Himalaya runs to the north of this tract, so that the strata traversed by the alignment are entirely of the Sub-Himalayan (Tertiary and Recent) types,—mainly Siwaliks, but with rocks of the Nahun group coming in at intervals.

After crossing Chakki Khad, 7 miles east of Pathankot, the line bends southeast *viâ* Gareli Khad, across the open alluvial valley to the Ban Ganga at Haripur (Mile 46). Throughout this portion of its course the line is sited on the recent alluvium and alluvial conglomerate which covers the valleys of the Sub-Himalaya. From Haripur it turns northeast up the winding gorge of the Ban Ganga River, throughout which a fine section of upper Tertiary massive blue-grey and yellowish sandstones is seen; these are well-jointed, and usually fine-textured, though sometimes including quartzite pebbled

associated with red and green clays. These rocks crop out as a broken anticline which crosses the Ban Ganga in a N.W.—S.E. direction, about one mile northeast of Haripur, the strata dipping steeply to the southwest in the section to the south of the anticlinal axis, and to the northeast in the main section towards Kangra. Massive sandstones predominate in the vicinity of the anticlinal axis, but in the Haripur section, and again from Chatrah to Daulatpur, approximately equal thicknesses of sandstones and clays alternate. Throughout a large portion of the tract, therefore, the railway is running at right angles to the strike of the strata, and by taking precautions against erosion and local landslips in the intervening clay beds, which might undermine the railway, and by cutting the line well into the massive sandstones of the valley sides, it should be possible to secure a sound foundation. In those instances where the proposed railway and the river follow the strike of the rocks, the undercutting of the sandstones and consequent slipping of the clays below, should be guarded against. Advantage has been taken, along several portions of the alignment, of flat alluvial terraces high up on the sides of the valley. Between Mile 52 and Bathu Khad a faulted anticline crosses the river in a N.W. by W.—S.E. by E. direction, as a result of which the jointed sandstones of the vicinity, especially where they dip down the steep southern slopes of the gorge, will necessitate a deeplycut platform in order to obtain sound foundations. Before reaching Daulatpur a short tunnel is required; this will traverse the steeply-dipping massive sandstones and clays almost at right angles to their strike, and except at the Daulatpur end where the clays predominate, it should be safe unlined. The railway leaves the Ban Ganga south of Daulatpur, and continues north to the ridge south of Kangra, through which the main tunnel, about 400 yards in length, is to be excavated. The ridge is composed almost entirely of massive conglomerates and pebble-bearing sandstones, comprising well-rounded water-worn pebbles, ranging up to a foot in diameter, mainly of quartzite, embedded in a slightly calcareous grey sandy matrix; among these conglomeratic beds softer argillaceous bands are intercalated. The conglomerate shows no marked planes of bedding or jointing, but on the whole dips gently to the N.N.E. It seems probable, in Mr. Gee's opinion, that except for protection against occasional falls of boulders from the roof of the tunnel, very little lining will be required. Trouble from water is considered

unlikely. From the northern end of the tunnel the line continues across the boulder alluvium and conglomerate for a short distance to Kangra Station.

From Kangra to Negrota and eastwards to Negrota Pass, the Kangra Valley is covered largely with clayey alluvium, including large boulders of porphyritic grey granite gneiss, forming a relatively level floor to the wide open valley. Across this the railway continues, and except for the foundations for bridges across the Jangal River and its tributaries, the work should be simple. Bending south through the Negrota Pass (Mile 70—75), the Tertiary strata again crop out. They include, mainly, massive sandstones, in most cases dipping at a moderate angle into the northeastern hillside, so that on the whole the slopes appear to be quite stable. One instance is cited, near the village of Drang, where an apparent crack in a jointed sandstone was observed, and should be avoided. As the Neogal River is approached red and green clays again become intercalated with the massive sandstones.

From the Neogal River to Palampur and on to Baijnath the more open valley is again covered by a thick granite boulder deposit which a few feet below the surface consists of a relatively compact mass of boulders embedded in a matrix of similar decomposed rock. Provided the superficial layers of this alluvial deposit, which are liable to creep down the steeper slopes, are avoided, and the bridge foundations are carried well into the semi-consolidated rock below, there should be no danger of any such slips affecting these foundations.

Leaving Baijnath Station, Mile 88-2, the line crosses Banu Khad. The present site for the bridge is located largely on the softer argillaceous sandstones and red clays which occur beneath the harder massive sandstones on which the road bridge is founded. Continuing across to Bir Khad, the railway follows the strike of the massive sandstones and red clays which dip at a fairly steep angle down its southern slopes. The alignment should, according to Mr. Gee, be safe provided it is founded on the lower thick massive sandstones of the valley side, and not on the red clays and softer sandstones above. These latter beds have undergone considerable slipping on account of the undercutting of the river. In those places where the line curves across the strike of the beds care must be taken against loose jointed masses of the sandstones, which overhang the valley slope. At Aijhu the valley again widens and is covered by similar alluvial boulder deposits. The crossing

of the deep Bachgar Khad will necessitate precautions in the pier foundations in these thick boulder beds. Further east the massive Tertiary sandstones with interbedded clays, which are seen dipping into the hillside to the north, crop out in the banks of the Gugli River. Continuing to Shanan over the boulder-alluvium, no large streams are encountered.

Mr. Gee observes that many of the sandstones along the line should make useful building-stones for the upper parts of the bridges, and certain of the clay-alluvium should make quite good bricks. A small quantity of limestone is being obtained from among the boulders of the river alluvium forming the banks of the Jangal River. Outcrops of useful limestone were noted along the hillside to the north, between the Bachgar Khad and Harabagh near Shanan.

The Kangra Valley area being subject to intermittent earthquakes, the question of precautionary measures is one of the points to be considered. Nothing can of course eradicate this risk but simple precautions are possible and Mr. Gee makes the following suggestions regarding the location and the construction of the line :—

(1) The edges of precipitous cliffs and of terraces, notably the unconsolidated alluvial deposits, should be avoided. (2) Similarly the end piers of bridges should be located a short distance from the edges of the stream banks. (3) Positions directly beneath cliffs or steeply-inclined slopes composed of such unconsolidated deposits, would be liable to damage from slips from above. (4) All structures, bridges, etc., should be located on stable rock-outcrops whenever possible, and not on the alluvium. (5) If stone is used in building, only small or medium-sized well-trimmed blocks should be used. (6) Steel trestle bridges are a suitable type of structure.

Mr. Gee indicates that there is little danger of landslides taking place in the hills neighbouring the railway sufficiently large to cause local floods over the alignment.

Shanan Hydro-Electric Project, Mandi State, Punjab.

During the months of May and September, Mr. E. R. Gee visited Shanan, Mandi State, to advise on certain questions which had arisen in connection with the Punjab Hydro-Electric Project. These points included :—

(i) An examination of the trial pits along the pipe-line.

(ii) The location of the surge-shaft.
(iii) The location of limestone for lime-burning.
(iv) The location of suitable sandstone for building near Shanan.
(v) The location of good supplies of sharp sand.
(vi) The geology of the Tunnel Section.

(i) From the examination of the trial pits and from the general evidence of the hillside exposures, it appears that the foot of the spur and the valley below, on which the Power Station is sited, are covered with a thick deposit of unconsolidated granite and quartzite boulder alluvium. The boulders are often of great size and are embedded in an uncemented sandy matrix. In the vicinity of the main Guma Road, large angular blocks of Tertiary sandstone crop out, though they are disposed very irregularly and do not suggest *in situ* outcrops. Above the main road to a point just below Trial Pit No. 2., the evidence of the trial pits and surface exposures suggests a fairly thick covering of slipped scree material in the nature of slate fragments embedded in an argillaceous matrix. The hill-slopes are cut up by a number of roughly parallel terraces into narrow strips of arable land, and any rock occurring near the surface would in all probability have been exposed by the repeated cutting and clearing of the hillside; none, however, is seen. Just below the group of huts between Pits Nos. 2 and 3a, is an apparent outcrop of hard, blue-green indurated slate-rock. Higher up the slope to the Tunnel Exit, the spur appears to be composed of the flaggy slates, considerably jointed, and covered at intervals by several feet of similar scree debris.

(ii) Shanan spur, above the Tunnel Exit, (R. L. 5,650 feet), is composed of a lower series of flaggy slates and phyllites, a quartzite band from 150 to 200 feet thick, and an upper series of micaceous gneisses and schists. The surface site of a vertical surge-shaft was required, along the line of the main tunnel, so that the shaft would meet the tunnel in the middle of the hard quartzite band, which would constitute sufficiently strong rock-material to resist the pressure of the water at the junction of the tunnel and shaft. If the tunnel is converted into a pressure-tunnel these pressures will obviously be very considerable. A large-scale map, 8 inches-to-one-mile, was made of the spur, showing the outcrops of the quartzite band on either side down to the valleys below. From this a section of the spur along the line of the tunnel was plotted. From

his section the base of the quartzite—a white and yellow massive crys-alline variety, considerably jointed—was seen to crop out about 475 eet above the Tunnel Exit, and to continue, at first with a slight outhwesterly dip, afterwards almost horizontally, above the tunnel. A small cross-fault, possibly represented along the tunnel line by a zone of shattering, runs through the strata. Further northeast he quartzite inclines gently to the north-north-east, the angle of lip increasing in this direction and bringing the quartzite nearer he tunnel; eventually the quartzite intersects the tunnel at a point about 2,650 feet from the Tunnel Exit. The quartzite will be en-ountered in the tunnel for a distance of about 480 feet, beyond which the felspathic gneisses and micaceous schists will be met with. Jp to the point of entering the quartzite, the tunnel will pass mainly hrough the flaggy slate beds, all showing definite lines of cleavage hough some more shattered than others. But from the outcrops along the sides of the spur, it is probable that before reaching the quartzite band a more massive, hard, epidiorite rock, intercalated n the slates, will have to be passed through.

It was obvious from the plotted section that in order that the urge-shaft should meet the tunnel in the middle of the quartzite t must be located at R. L. 6,814 feet along the ridge, above the line of the tunnel, at a distance of 2,970 feet, measured horizontally, rom the Tunnel Exit. The tunnel would be encountered at R. L. 5,850 feet, indicating a shaft of a total depth of 964 feet. Such a haft, from an engineering and financial point of view, was, however, mpracticable.

A suitable site as regards the engineering factors governing its ocation had been previously selected by the engineers in charge of he scheme at a point about 650 feet above the Tunnel Exit, and it was hoped that this site would also comply with the desired geologi-cal conditions. It was obvious, however, that such a shaft, 481 eet deep, would pass through the quartzite for the upper 160 to 170 eet and would then encounter the cleaved slate-rocks.

Since the surge-shaft must in any case be located fairly near he Tunnel Exit, Mr. Gee considers that the safest and most practical lan would be to drive an adit from this exit along the line of the roposed tunnel, without delay, up to the limiting distance for the urge-shaft site. The strata could then be carefully examined and he best site selected. If the hard, massive, epidiorite rock is passed hrough in this distance it is probable that it would make a very

secure site for the junction of the shaft and the tunnel. The question of necessary reinforcement or lining to prevent leakage, can then be discussed.

(iii) To the north of the Tertiary sandstone and clay outcrops on the hill-slopes above the Baijnath-Mandi Road, between the Bachgar Khad and Harabagh, is a discontinuous band of limestone varying considerably in thickness and in quality. Above the villages of Baterh and Ladrun it forms precipitous cliffs, occurring as a dark grey crystalline dolomitic limestone of the following composition :—

SiO_2 (treated with H.F.)	1·70
Fe_2O_3 and Al_2O_3	1·37
CaO	31·80
MgO	19·92
Loss on ignition (CO_2 and water)	46·12
	100·91

A better quality limestone occurs above Harabagh at the present site of the quarry and the lime-kilns. It crops out massively, dipping very steeply to N. 10° E., but is cut off obliquely by a fault bringing in the white quartzites further east along the ridget, A considerable quantity of limestone is. however, available. The rock is fine-textured, cream-coloured, and only moderately hard. It is associated with impure gritty bands which can be hand-picked from the better quality material; the latter, gives on analysis :—

SiO_2 (treated with H.F.)	13·66
Fe_2O_3 and Al_2O_3	4·50
CaO	37·79
MgO	5·04
Loss on ignition (CO_2 and water.)	35·47
	96·46

In addition a band of grey crystalline limestone from 8 to 10 feet thick, was located among the steeply-dipping slates on the eastern slopes of the Uhl River east of Barot. It is veined with white quartz which might be hand-picked from the broken rock. Specimens of the limestone on analysis showed it to be a fairly pure dolomitic rock, losing from 37 to 43 per cent. by weight on ignition.

(iv) On the whole the Tertiary sandstones of the Shanan area are of the soft felspathic argillaceous types, unsuitable for building. Among

these, however, harder bands of blue-grey fine-textured varieties occur, which are relatively hard and should yield useful building-stone.

In the ridge just south of the Power Station site two such bands of stone were located, one about 4 to 6 feet in thickness and the other rather thicker. These beds dip steeply to the southeast, striking very obliquely into the north side of the ridge. In the bend of the stream a short distance to the southwest other hard sandstones were located.

(v) The only source of sharp loose sand in the vicinity appears to be from the matrix of the boulder conglomerate which fills the valley. Such limited deposits had been located by the resident engineer. Some of the better quality sandstones might yield a fine sand on crushing, but this would probably need washing to free it argillaceous portion of the sandstone.

(vi) The tunnel follows a general northeasterly direction through the Shanan-Uhl River ridge from the 5,650 foot level on the south-west side above Shanan, to the 6,000 foot level close to the Uhl River at Ghog. Its total distance is about $2\frac{4}{5}$ miles.

The section as far as the upper limit of the quartzite from the Tunnel Exit end has been mentioned; this point will be passed about 3,200 feet from the Exit. After a thin series of dark shales the tunnel will pass through the harder felspathic gneisses and inter-banded soft micaceous schists, for a considerable distance, until the grey porphyritic granite-gneisses of the centre of the ridge are met with. The gneisses and schists dip at a steep angle to the northeast, as do the massive granites which follow. On the north-east side of the ridge these granite-gneisses will again give place to micaceous schists, the softer well-foliated types predominating all down the slopes, until we approach the Uhl River. Here fine quartzitic schist is intercalated with the softer beds and comprise the northeastern portion of the tunnel and the Tunnel Portal spur. In the Uhl River these beds dip at an angle of 67° in a direction S. 40° W., and continue southeast to form the cliffs of the dam-site.

It is anticipated that the whole of the tunnel, excluding the portion excavated in the granitic rocks, will require to be lined. The question of lining that part of the tunnel which passes through the granite, will probably arise if the tunnel is converted into a pressure tunnel at a later date.

The question of water-trouble during the excavation of the tunnel will largely depend on the jointing of the rocks. It is probable that water will be met with in the vicinity of the quartzites and again in the finely foliated mica-schists on either side of the massive granites.

Subsidence, Khewra Village, Salt Range, Punjab.

Dr. Fox was deputed to investigate a subsidence at Khewra mining village, Mayo Salt Mines. The village is situated on the left bank of the Khewra gorge on the Salt Marl or Saline series. The Saline series, containing several seams of salt, strikes in a west-south-west direction across the gorge. It appears certain that one of the thicker seams of salt underlies the portion of the village which has suffered subsidence.

Dr. Fox recommends that the stream water should be drawn off under the bed of the stream by means of a well on the bank at a suitable place. An alternative and perhaps better suggestion is an infiltration gallery ending in a tunnel driven from a lower level.

Fire-clay.

Pakokku and Lower Chindwin districts; Burma.

According to Mr. Barber, a coarse pottery is made from the Pegu clays at several villages in the Pakokku district, the chief centre being Sattwa (95°7′; 21°39′), and in the Lower Chindwin district the chief centre being Salingyi (95°5′; 21°58′). At Sattwa the industry is restricted to the manufacture of small bowls and household utensils, but Salingyi specialises in the production of large "Pegu Jars" which are exported to many parts of Burma.

The wet plastic clay is moulded to the desired shape on a potters' wheel, and the vessels thus prepared fired in large kilns after a preliminary baking in the sun. Before baking, the clay is bluish-grey in colour but after firing assumes a rich brick-red tint.

Iron.

Keonjhar State: Bihar and Orissa.

The survey of the Iron ore deposits of Bihar and Orissa and its Federated States was continued during the season by Mr. Jones and his party. A number of good deposits were recorded in Keonjhar State.

Kaolin.

Keonjhar State; Bihar and Orissa.

On a hill-slope north of Kuldum (22° 6′; 85° 30′) in Keonjhar State Dr. Krishnan observed a small and unimportant deposit of impure kaolin, derived from basalt.

Castle Rock, Kanara district; Bombay.

During the season Rao Bahadur Vinayak Rao investigated some kaolin deposits near Castle Rock, Kanara district, Bombay. The country in the neighbourhood consists of hills with an elevation of 2,500-3,000 feet over all of which laterite is found. Laterite is also found in the valleys and the rocks—Archæan gneisses and granites with a few bands of Dharwars—are highly decomposed. The laterite on the hills is from 10 to 30 feet in thickness and has probably a greater thickness in the valleys.

The kaolin, evidently the result of pneumatolytic action, is found below the laterite and on the gneisses. The chief occurrence is at mile 2-4 on the railway line about 1½ miles west of Castle Rock station. It is well exposed on the hill-side opposite the outer railway signal, forming a conspicuous feature, and extends into the valley below. There is a cap of laterite on top and decomposed gneiss at the base. The length of the exposure is about 235 feet. The kaolin is pure white in patches and stained red at the eastern and western extremities.

Some pits were put down on this slope to a depth of 9½ feet. The quantity of kaolin available is large as it extends from a height of nearly 100 feet into the valley below. Tests were carried out in the Geological Survey Laboratory with samples from three of the pits and gave the following results:—

Plasticity.	Measurement of bricks.		Colour.	
	Before heating.	After heating.	Before heating.	After heating.
Good	$20 \times 10 \times 4$ m.m.	$19{\cdot}5 \times 10 \times 3{\cdot}5$ m.m.	Light grey.	White.
Do.	Do.	$20 \times 9{\cdot}5 \times 3{\cdot}5$ m.m.	Do.	Do.
Do.	Do.	$20 \times 10 \times 3{\cdot}5$ m.m.	White.	Do.

All the bricks were heated in a blow burner for 20 minutes at a temperature of about 1200° C.; none showed any signs of fusing.

An analysis of the Castle Rock kaolin—presumably from this deposit—made by the Superintendent of Pottery in the School of Art, Bombay, gave the following results :—

	Washed.	Crude.
Loss on ignition	10·8	7·3
SiO_2	53·8	69·3
Al_2O_3	32·6	20·5
Fe_2O_3	1·5	2·0
CaO	1·3	0·9
MgO	0·0	0·0
Na & K	..	..
	100·2	100·0

This compares favourably with analyses of English, Chinese and American kaolin, the Chinese kaolin containing a higher percentage of silica. The Castle Rock kaolin would in the opinion of Mr. Vinayak Rao be very suitable for pottery.

Other occurrences of small extent were found at Mile 4, east of Castle Rock station on the way to Almod. Here the material is not so pure as the kaolin at Mile 2-4 but the deposits should be opened up. In the valleys below Castle Rock traces of kaolin were found, and Mr. Vinayak Rao is inclined to think that there is a continuous band of it in the valley west of Castle Rock station below the laterite.

Limestone.

(*See* BUILDING MATERIALS AND CEMENT MATERIALS).

Kanara district, Bombay.

Mr. Vinayak Rao reports a large mass of limestone of Dharwar age in the Nagjhiri valley, south of Kulgi, and in the valley of the Kalinadi River below its junction with the Nagjhiri.

Manganese.

Keonjhar State: Bihar and Orissa.

Manganese was noted by Dr. Krishnan, associated with certain classes of iron ores segregated from the purple shales of the Iron Ore series, in Keonjhar State, Bihar and Orissa.

Kanara district; Bombay.

The manganese deposits in the high forest areas of Dandeli, Virnoli and Kulgi, Kanara district, Bombay, were inspected by Rao Bahadur M. Vinayak Rao (Old Bombay Survey sheet 278, 1 inch = 1 mile). The area consists of a plateau with an average elevation of about 2,000 feet with low hill-ranges on either side running in a N.N.W.-S.S.E direction with a maximum elevation of 2,436 feet. Owing to heavy rainfall there is dense jungle with a thick soil-cap and exposures are few. The following formations were noticed:

1. Laterite.
2. Gneisses and granites with pegmatites . . . Archæan.
3. Limestones, shales, slates, argillites and quartzites . . . . . Dharwar.

The laterite is found throughout this area capping the high hills. Both the massive and detrital varieties are found. It extends northward through the Supa *petha* and beyond into the Belgaum district. The width is variable but in the plateau it is probably not more than 500 yards wide. It is more extensively developed further north.

Though the gneisses and granites are considered by Mr. Vinayak Rao to be younger than the Dharwars there has been no evidence so far of their intrusive nature into the latter. The gneisses are mostly fine-grained rocks and occur in the lower ground; near Londa to the north in sheet 277 they are found in higher ground. The pegmatites contain muscovite near Virnoli. The granites and gneisses appear to belong to the younger group of the Archæans.

The Dharwars consist of limestones, shales, slates, argillites and quartzites. They occur just below the laterite caps and appear to be manganiferous.

Deccan Trap was found in small patches mostly in low-lying ground. Dykes in this area are probably of the same age as the Deccan Trap.

Manganese ores are found in the laterite capping the hills. They appear to be about 100 feet wide in places: in others they are only four to five feet in width. At the time of Mr. Rao's visit there was only one concession being worked and there the surface had been barely scratched. The depth

of the ore-body which is of the lateritoid variety is likely to be about 25 feet—in some cases less. The ore is easily mined, requires very little dressing and is said to contain about 50 per cent. manganese. The area being within 120 miles of the Portuguese port of Mormugoa, there is keen competition to secure mining concessions.

The ore is mostly psilomelane with a little braunite and wad; pyrolusite was found in one place. The Dharwar rocks originally contained manganese and these appear to have been deposited in the laterite by capillary action as suggested by Dr. Maclaren. Pebbles of manganese ore were found in the detrital laterite in the Virnoli plateau and in other places thus proving the younger age of the detrital laterite.

Mr. Vinayak Rao reports that manganese is found in the following places, sometimes occurring as parallel bands:—

(*a*) About 1½ miles south of the abandoned village of Kaola above the limestone caves in the valley of the Kalinadi.

(*b*) In the valley of the Chulchulpani.

(*c*) Along the top of the ridge where the boundaries of the villages Amgaon, Shiroli and Sanmaga meet.

(*d*) About 1 mile from the village of Potoli north of the road.

(*e*) West of Pardhana north of the main road between miles 13 and 14.

(*f*) Several bands west of Virampoli on the track to Bapheli.

(*g*) West of Hudsa on the cart-track to Joida.

(*h*) East of Joida (these bands continue northward and are found in the road between Potoli and Joida between miles 18 and 19).

(*i*) Near Kulgi.

(*j*) In the gorge of the Nagjhiri.

(*k*) Near Gund.

Deposits (*a*) to (*f*) are in the high forest areas; the others are west of this. Besides these there are deposits in the Supa *petha* extending from about 10 miles north of Supa to near Castle Rock and northward into the Belgaum district; the deposits of the latter area appear to be as good as those elsewhere.

The manganese occurrences are in laterite which does not support the growth of valuable timber, and occupy a very small area. They occur as small patches with a maximum thickness of about 30 feet and a width of about 100 feet. There is therefore no question of manganese mining causing the disappearance of the Reserved Forests.

Marble.

Mewar (Udaipur State): Rajputana.

The Rajnagar marble is exposed over wide areas in the neighbourhood of Nathdwara (24° 56′ : 73° 52′), Rajnagar (25° 4′ : 73° 55′) and Kelwa (25° 9′ : 73° 53′) in the Mewar (Udaipur) State, and has in the past supplied material for the great embankments of the Raj Samand and the Fateh Sagar, the palace at Udaipur, the new palace in the Chitorgarh fort, and innumerable temples and *chhatris* all over the State. In spite of the vast amount which has been used in the past, it is difficult to see where it has all been taken from, so small are the quarries; most of it, moreover, must have been out-crop material. The amount available is literally inexhaustible.

According to Dr. Heron it is worked only at Rajnagar where the quarrying is a free grant to a few Mahomedan families; at present burning the waste stuff for lime brings more profit than quarrying. The stone is said to be supplied to the Mewar Durbar at Rs. 1-2 per cubic foot, and to the public at Rs. 1-8 to Rs. 1-10 per cubic foot.

Blocks of 6 foot a side are not uncommon, and very large slabs and blocks are shown to visitors in the Bari Mahal garden of the Old Palace of Udaipur. Although slightly coarse in grain for statuary work according to Italian and Grecian standards, it is a first-class marble, pure white and free from the grey cloudiness of Makrana marble; it does not appear to turn yellow with age. Chemically it corresponds very nearly to dolomite. The distance of the quarries from the railway—20 miles in a direct line to Nathdwara Road Station (Maoli)—and the long railway lead to any market for the stone, are the chief impediments to its wide use.

Mica.

Ajmer-Merwara: Rajputana.

At Bisundni (25° 44′ : 75° 12′) in Ajmer-Merwara, a mica mine, managed by the Rajputana Mineral Co., Ltd. of Ajmer, was inspected by Mr. Bradshaw. Some fifteen years ago this was worked in open quarries but the mica is now extracted from levels which run out from

vertical shafts 30 to 40 feet deep. About 20 men are employed and the average daily output of the mine is about 40 lbs. of saleable mica, which is carted to Nasirabad Railway Station *via* Kekri. The mica is a "spotted ruby", and is hand-sorted into sizes 1 to 6, and "special" the latter may be up to 16 inches square. The very coarse pegmatite in which the mica occurs consists of quartz graphically intergrown with two kinds of felspar, and large prisms of black tourmaline and beryl.

Ochre.

Kanara district, Bombay.

Mr. Vinayak Rao observed red* and yellow ochre of good quality in the railway cuttings between miles 4 and 5 east of Castle Rock Station, in the Kanara district of Bombay.

Petroleum.

Drig Road, Karachi, Sind.

A boring for water was commenced by the Public Works Department of Sind in 1923 close to the sixth milestone between Karachi and Drig Road. Saline water was encountered at various depths and a little pyrite and sulphur drawn out of the core. In 1925, between the depths of 720 and 733 feet a limestone was met with having a strong smell of crude oil. At 815 feet the boring entered a soft brownish sand, which is also reported to have had traces of crude oil in it. At 826 feet an artesian flow of very saline water was struck from a grayish sand. To investigate the possibility of striking petroleum in commercial quantities by deepening this bore or by boring on a larger scale, Mr. H. Crookshank was deputed to visit the area.

Mr. Crookshank has submitted a report and map of the area, and it is hoped to publish a brief note on his results. The boring is calculated to have entered the Upper Nari series at 815 feet, the petroliferous limestone belonging to the Gaj. Mr. Crookshank found the structure of the rocks to be that of a dome with gentle dips in all directions, and eminently suitable for the storage of oil. The longer axis of the dome runs N.E.-S.W., its pitch to the S.W. being very small. The present boring is situated 1½ miles from the crest of the

dome, and is therefore not the most suitable location for an oil test. The best site for a test is the summit of the dome, and, as the rocks are potentially petroliferous to a depth of over 5,000 feet, if a test is desired the boring should be continued to the maximum depth possible. No evidence of the occurrence of oil was seen by Mr. Crookshank either at the boring or in the form of surface seepages, but there seems no reason to doubt the identification of the petroleum indications by the engineers in charge of the boring.

Pyrite.

North Arcot district, Madras.

The pyrites deposit near Polur in the Tanniar Forest Reserve, North Arcot district, Madras, was opened up by Field-collector A. K. Dey under the superintendence of Mr. Vinayak Rao. The deposit is 4 feet 6 inches in width, and was excavated to a depth of 16 feet. It extends in a N.E.-S.W. direction; further work will be carried on during the next field-season and the results ultimately published.

Salt.

Pakokku and Lower Chindwin districts; Burma.

Salt is worked extensively from clays of the Pegu series at Kyaukka (95° 9′; 21° 35′) in sheet 84$\frac{O}{2}$ (Pakokku district) and Salingyi (95° 5′; 21° 58′) in sheet 84$\frac{O}{1}$ (Lower Chindwin district). At the former locality clay containing the salt is placed in small earthen pots in the bottom of which a small hole has been made. Water is then poured into the pot and allowed to percolate through the clay, the resulting brine from several such pots being collected in a common receiver by means of a bamboo pipe and taken to the village, where the salt is extracted by evaporation.

At Salingyi a similar process is conducted on a large scale. Here saline water, obtained from wells in the Pegu clays, is enriched by percolation through a soaking bed prepared from loosely piled salt-bearing clay. The concentrated brine thus obtained is collected in several earthen pots situated at the periphery of the soaking bed, and the salt extracted by evaporation.

At the commencement of the season Dr. Dunn examined and mapped the salt seams in the Khewra Mine, Salt Range, Punjab, in order to advise the mine authorities on the trend of the seams. The deposits were found to be acutely folded, and the two main seams—the Buggy and Pharwala—are regarded by Dr. Dunn as in reality the two limbs of a recumbent syncline; for purposes of mining at any rate they may be regarded as two seams. As a result of an easterly pitch along the fold the two seams are widely separated at the eastern end of the mine, and if work is continued in that direction they may have to be treated as two distinct mining propositions so far as ventilation is concerned. The seams, it is thought, will ultimately be cut off to the east by severe faults which crop out at the surface several hundred feet beyond the present end of the drifts. The true Pharwala seam—the equivalent of the Buggy on the lower limb of the fold—is, as yet, undeveloped.

Khewra, Salt Range; Punjab.

With regard to prospecting under the western hill, faulting and the solution action of meteoric waters have considerably disturbed the salt seams. To prospect the hill a drift running south-west from near the present end of the prospecting tunnel in the hill was advised. Such a drift will cut the marl and salt seams nearly at right angles.

At Warcha outcrops of salt to the north-east of the present mine were examined by Dr. Dunn. There is here apparently a large amount of excellent salt, but in a somewhat inaccessible position. Before the exploitation of such a deposit is taken up it would appear advisable to investigate the more accessible outcrops of salt along the Salt Range, and to determine which are likely to be the most promising from an economical point of view. Along the north-west of the Warcha Mine the seam is terminated by a large fault—apparently a thrust-fault consisting of a tenacious clay or "pug" up to 100 feet thick. This is reported to be holding up the drainage water from some distance around. A fresh water spring occurs just above the fault on the hill-side above the mine, and limestone overlies the fault. Hence it is inadvisable to cut through the fault in the mine workings owing to the danger of flooding.

Warcha Salt Range; Punjab.

Deposits of salt around the Kalabagh Hill, on the west bank of the Indus, were also examined in order to determine the advisability of stopping the present workings to the north and commencing a new

Kalabagh, N. W. Frontier.

mine on the south side of the hill. A good deposit of salt on this side would lower transport costs considerably, as a railway bridge is to be constructed close by across the Indus, and the mine would be almost alongside the new railway. Excellent outcrops of salt were noted, but folding is, according to Dr. Dunn, considerable although the strike is apparently fairly regular and the amount of folding seems less than on the north side of the hill. Short prospecting tunnels were suggested, before money is spent on the longer tunnel necessary for large production.

Shahpur district; Punjab.

During the early part of the month of October Mr. E. R. Gee was deputed to the Salt Range to report on the possibilities of workable deposits of rock-salt to the south of the Jansuk Gorge, near Warcha, Shahpur district, Punjab.

The following formations were met with during this survey:

3. The Permian limestones.
2. The Purple Sandstone and Clay series.
1. The Salt Marl series.

The area noted lies in the vicinity of the south-flowing Warcha River and the west-flowing Jansuk tributary. The structure is that of two pitching anticlines, whose axes follow the courses of these two streams. In the case of the former the anticline is pitching upstream to the north-north-east and the lower beds of the centre of the fold, that is to say the salt and gypsiferous marls, are exposed in the main stream-course. The beds are, however, very much shattered and faulted as a result of the crushing which has occurred, so that the salt outcrops in the main Warcha gorge above its junction with the Jansuk do not appear to extend far into the hillside before they are cut off by a fault or zone of shattering. The second anticline follows the Jansuk stream, pitching upstream to the east-north-east at a fairly steep angle. A zone of crushing follows the anticlinal axis, running along the northern side of the stream. To the south, in the southern limb of the anticline, the strata dip steeply to the E. S. E. near the head of the anticline, but further west, between Guard Posts Nos. 5 and 7, the inclination is to the S. E. and S. S. E. at a gentler angle, in the neighbourhood of 30°. As a result, on the southern slopes of the Jansuk, in the western portion of the tract, the scarlet salt-bearing marls continue up the slopes to a height of 400 feet above the stream-bed, and are capped by the purple sandstones and clays, and the

massive Permian limestones. The marls of these southern slopes are slightly complicated by two small faults.

Beneath these upper strata the salt marls, including at least one thick seam of good quality rock-salt, extend for some distance to the southeast. At a distance of about 1,700 feet to the south of Guard Post No. 6 these salt-bearing strata are cut off by a N.W. to S.E. or W.N.W. to E.S.E. fault, downthrowing to the northeast, and bringing in the purple sandstones and limestones to the south. A second fault, limiting the workable area of the salt, follows a south-south-easterly direction along the upper course of the main tributary to the Jansuk which flows from the west side of the hill Bhussi. This fault downthrows to the west. To prove this suggested area of workable salt three exploratory drifts were indicated. It was advised that these drifts should be commenced from the upper part of the seam of salt on the southern slopes of the Jansuk, as there was evidence of the lower salt-outcrops, being cut off by faults a short distance within the hillside.

Salt is at present worked on the western side of the main Warcha Gorge just about the village of Rukhla, the salt dipping N. 25° W. into the hillside at an angle of from 30° to 45°. To the southwest of the present workings are old Sikh workings followed further south-west by systematically worked dip workings, for the present abandoned. A fault, seen in the northernmost chambers of the present mine, appears to cut off the salt in this direction. At first it follows a direction N. 55° W., but to the west of Chamber No. 14 it apparently swings round to the north. A second fault, with typical fault-marl, comes in a short distance to the west, in Chambers 8 and 9 ; evidence of this fault is seen on the surface. Both faults have a marked hade—as much as 50°.

In the old Sikh workings and to the south-west the dip is fairly constant to the N. N. W. but in the extreme western portion of the abandoned dip-workings it is swinging round to the W. S. W., at 25°. This is in accordance with the surface evidence. The purple sand-stones and clays and the limestones above are seen, above the village of Rukhla, to dip steeply to the west, but are cut off by a fault, downthrowing to the south-east, and following a general N. N. E.'ly direction across the slopes. Much depends on the hade of this fault as to how soon it will be met with in the extension of these western workings, though doubtless the dip will be found to be steep to the west and west-south-west as the mine is extended in that direction.

The prospects of tapping the salt deposits on the west and north-west side of this fault by an adit sited in the lower slopes behind Rukhla village are considered to be inviting.

Sandstone.

(*See* BUILDING MATERIALS).

Steatite.

Mr. Bradshaw reports that the steatite mine of Jeoria (25° 26′; 7° 5′) in the Mewar State of Rajputana is now closed owing to a lack of demand for the mineral (*see* General Report for 1925, *Rec. Geol. Surv. Ind.*, vol. LIX, p. 52).

Mewar State; Rajputana.

Water.

As a result of an enquiry by the District Engineer, East Indian Railway, Dhanbad, regarding the selection of suitable sites for wells to supply the railway staff with water for household purposes, Mr. E. R. Gee was deputed to visit Dhanbad during the month of January. The district around Dhanbad had previously been visited by Mr. E. L. G. Clegg in 1921, who had made a geological map of the area on the scale of one-inch-to-the-mile, and had chosen a site for a well to supply water to the new Indian School of Mines which has now been completed at Dhanbad.

East Indian Railway, Dhanbad, Manbhum district, Bihar and Orissa.

The rocks of this area include a series of gneisses of varying types. A coarse granitoid gneiss is predominant, with finer quartzitic varieties, passing into quartzitic micaceous schists, with which are associated occasional bands of dark hornblende schist. Into these rocks have been intruded irregularly shaped massive amphibolites, together with a number of shattered quartz-veins, the latter occurring, as Mr. Clegg suggested, along lines of vertical movement.

It was pointed out by Mr. Clegg that these quartz-veins, being considerably fractured, would largely influence the underground drainage which percolates through the relatively impervious gneisses. This was borne out by the evidence of the wells already in existence, all those wells which yielded a good supply of water throughout the year being located in the vicinity of the quartz-veins,

The site chosen by Mr. Clegg was similarly selected, and has further evidenced this effect of the quartz-veins. The uncompleted well having reached a depth of 112 feet, the water-level was about 40 feet below the ground surface, and although no actual test had so far been carried out, a very efficient supply was anticipated.

Another important point which appears to influence the underground drainage to a considerable extent is the occurrence of the massive amphibolite rocks among the quartz-veined gneisses. These Mr. Gee suggests would act as a dam to the underground seepage, and the general direction of percolation being to the south-east, he considers that a rise of the water-table would take place on the north side of these intrusive basic rocks. He sites the example of the large Ground Tank about ½ mile east of the railway station; this appears to be fed largely by springs which arise against the amphibolites occurring across it and again on the south side of the tank. Bearing these two considerations in mind he selected sites in the quartz-veined gneisses in the vicinity of the amphibolite rocks near the Ground Tank, and again about ½ mile to the west of the station, such places being also convenient for the requirements of the company.

It is proposed to obtain the water by sinking several tube-wells by means of a Calyx drill, from 8 to 8½ inches in diameter, to a depth of about 300 feet if necessary, and forcing the water up by compressed air. The chief source for the influx of water into the wells will be the open planes of shattering within the quartz-veins and the adjacent gneisses, so that the rate of supply will largely depend on the number of such channels which are intersected during the boring. Mr. Gee therefore advises, that, should a well of the proposed diameter prove inefficient, a wider shaft should be constructed on the selected site.

Kathiawar; Bombay. During February Mr. West examined five borings for water, four in Kathiawar and one near Bombay.

Dhandhuka (*see* General Report for 1925, *Rec. Geol. Surv. Ind.*, vol. LIX p. 61) was again visited, and the cores examined from the depths of 1,213 to 1,916 feet from the surface. In the portion of the boring examined last year, Mr. West identified 18 flows with an average thickness of at least 50 feet. During this second visit fifteen flows, one volcanic agglomerate, and two Intertrappean beds were identified; the flows have an average thickness of 34 feet, the volcanic agglomerate is 73 feet thick, whilst the Intertrappean

beds are 42 feet and 102 feet thick, though the latter, being at the bottom of the boring, was not fully seen. The Intertrappean beds are grits and sandstones, and contain some pebbles of trap.

While the majority of the upper flows as seen last year contain olivine that is always altered, in the lower flows it is quite commonly fresh. These latter are very similar to those seen at Botad last year —basic porphyritic olivine-basalts, with phenocrysts of olivine and augite. This boring eventually reached a depth of 1,951 feet, when it was abandoned. It is not certain whether it had then penetrated through the Deccan Trap. The last 35 feet are said to have been sandstone, but this may have been the continuation of the lowest Intertrappean bed.

A boring at Wadhwan Junction was found to have penetrated, first 40 feet of alluvium, then 312 feet of Deccan Trap, and then a set of white friable sandstones with purple and carbonaceous shales down to the bottom of the boring at 1,000 feet. The Deccan Trap includes three lava flows, three beds of volcanic agglomerate, and two beds of soft inter-trappean sandstones. The flows average 75 feet in thickness, and one of them is remarkably fresh with a light green olivine.

Jamnagar was next visited. This boring had been seen down to 782 feet last year. The depth of 1,020 feet was subsequently reached, but the cores from this last part had been thrown away. It appears that the boring was still in trap.

At Khambalia, 34 miles west of Jamnagar, a boring was put down to 710 feet. Thirty-four flows of an average thickness of 20 feet, and two beds of volcanic agglomerate of 5½ and 8 feet thick, were seen here. As at Jamnagar, the flows are characterised by a richness in zeolites, of which there is a great variety. Nearly all the flows are highly vesicular, and the variety with fresh olivine is absent.

Adatra, at the extreme N. W. corner of Kathiawar, was next visited. Here a boring had reached a depth of 390 feet. It penetrated shelly limestones rich in casts of lamellibranchs, gastropods and corals, followed by blue clays with some limestones and sandstones. These beds are presumably of Miocene age and it is supposed that the Deccan Trap occurs below them. Mr. West has submitted a short report on the possibility of obtaining water here, from which it appears that the chances of obtaining a good supply of fresh water are not at present very encouraging, though there are certain possibilities.

The last place visited was Panvel, 43 miles S. E. of Bombay. Here a boring had been put down to 413 feet, the place being nearly at sea-level. Unfortunately, the cores had not been carefully preserved, and little could be done. The boring was entirely through trap, a prominent variety of which was a rock rich in large tabular phenocrysts of felspar.

All these borings were put down for water, and all were unsuccessful. The boring at Wadhwan Junction penetrated the Deccan Trap, and from the sandstones below a supply of water could be obtained by pumping. This, however, was salt and brackish and quite useless for drinking. It is clear then that there is little hope of obtaining a supply of water from the Deccan Trap of this part of India ; and that if the Deccan Trap is penetrated any water obtained is not likely to be potable.

Dabheji, Jungshahi, and Ran Pethani, North-Western Railway, Sind.

In compliance with a request from the North-Western Railway Mr. A. L. Coulson was entrusted with an enquiry into the water supply of the Dabheji, Jungshahi and Ran Pethani area in Sind.

At Dabheji, it is considered that the sole practicable means of increasing the present supply of water from 80,000 to a possible 100,000 gallons daily, lies in the utilisation of better methods for the capture of the spring waters and the small amount of water present in the gravels of the Dabheji river.

At Jungshahi, it is recommended that the source of supply of the saline waters, contaminating the river gravel water, be closed down and that more extensive methods be adopted to utilise the water known to exist in the Jungshahi river gravels. By increasing and improving the present system of sumps and by adding three additional galleries it is considered that the total supply of 45,000 gallons daily will be increased to about 60,000 gallons of good water.

At Ran Pethani, where matters are merely in the experimental stage, alternative schemes and their relative advantages have been considered. The means adopted must be dependent upon the results of certain experimental tests, which, it is suggested, should be conducted for a prolonged period. Until these results are available it is difficult to estimate the possible resources of water ; but, by taking a mean of figures obtained from a comparison of the Ran Pethani river with the Malir and Jungshahi rivers, it is considered that the daily supply should be in the neighbourhood of 175,000

gallons. It is not possible to estimate the maximum output from the scheme suggested.

Mr. Coulson considers that the estimated daily output of Dabheji, Jungshahi and Ran Pethani, totalling some 335,000 gallons, though short of the required maximum daily output of 400,000 gallons, will be found to satisfy the railway needs for the Jungshahi and Dabheji area.

The waterless tracts of the Myingyan district.

In August 1926 a conference was called at Government House, Rangoon, to consider the question of the supply of water to the waterless tracts of the "Dry Zone" of Upper Burma. The Superintendent of the Burma Party of the Geological Survey of India, Dr. Coggin Brown, after briefly outlining the general geological conditions, expressed the opinion that it was necessary to consider each waterless area separately, and that little was to be gained by attempting to regard the problem as a widely general one. Dr. Brown undertook to supply such geological information as is available for the use of the water and public health authorities, provided he was given full particulars of the separate areas concerned.

Up to the end of the year under review such particulars had been received from the Deputy Commissioners of Myingyan and Thayetmyo respectively, the latter referring to the Allanmyo subdivision only. Owing to his local knowledge, Mr. C. T. Barber was entrusted with the preparation of the report on Myingyan; the other is being prepared by Dr. Coggin Brown.

Mr. Barber has shown that a study of the map of the waterless tracts of Myingyan district reveals that they are all situated on rocks of Irrawadian age, while those indicated as having an adequate supply lie either on Pegu rocks or on extensive areas of alluvium. The problem, therefore, as far as Myingyan is concerned, resolves itself into the question "Can potable water be obtained at a reasonable depth from the Irrawaddy rocks"? In the absence of data from wells sunk in the Irrawaddy rocks, there is little to guide one in any attempt to estimate the depth of the level of permanent saturation; in such porous deposits it may be considerable. The depth of the water-table is expected to have definite relationships to the underlying impervious Pegu strata and the water to percolate to the centre of the synclinal areas which the Irrawadian frequently occupies. The unconformity between the two rock groups and the

extremely false-bedded nature of the Irrawadian make it almost impossible to give reliable estimates of the thickness of the group and so of the depth of the water-table at the centre of the troughs. There is a further complication in the fact that the water of the Burmese upper Tertiaries is frequently saline. Mr. Barber concludes that the problem of obtaining water by boring in the Irrawadian is beset by great, if not insuperable difficulties. In the second part of his report each of the waterless tracts of Myingyan district is dealt with separately, and the localities suggested where the conditions are thought to be the least adverse for the purpose of sinking trial wells. Further than this it is impossible for a geologist to go at present. It is hoped, however, that, as the results of trial bores become available, further light will be thrown on the underground structures of these rocks, which will help towards the elucidation of this important question.

Taungtha township. The Taungtha township contains four waterless tracts as follows :—

1. *Sinthe.*—An area of 25 square miles with four villages containing 406 households. The shortage lasts for 3 months during which water has to be carried from the Tada Chaung, 3 miles away. The area consists of a shallow asymmetric syncline passing to the north-west between Tada and Kyamadwin. It pitches towards the north-west to an unknown extent. These conditions render the possibility of abundant supplies at reasonable depths remote.
2. *Taunglalin.*—An area of 20 square miles with 269 households—supplied from tanks which dry up in the hot season, when the nearest supply is $2\frac{1}{2}$ miles distant. The rocks of the tract are very contorted and the water in them is known to be charged with hydrogen sulphide. No remedy seems possible here.
3. *Minyin.*—A small area of 9 square miles with the large village of Tanaunggon (300 households) situated in it. It borders the Sinthe tract on the north, but is covered over the greater part of its expanse with a thin sheet of alluvium. It is usually possible to obtain limited supplies of potable water at shallow depths from such alluvial deposits.

4. *Thigon.*—Another small tract like Minyin, containing 298 households, whose greatest distance from a water supply in the hot season is 3 miles. The geological conditions are similar to those of the Minyin area.

Pagan sub-division.

The waterless tracts of the Pagan sub-division cover an area of about 400 square miles, within which there are six patches of good water supply and the riverine tract which extends from Singu to Mala. This area contains 5,389 households which suffer a temporary shortage of water for 3 or 4 months during the hot weather, when the local tanks dry up. At the same time many of the large villages are within comparatively short distances of the Irrawaddy River, or, of the wells of Kalade, Seywa, Taungbonywa, Nyaungbin and Ngalinbok. The oases of Kalade and Ngathayauk lie on alluvial patches of considerable thickness. The occurrence of water at some of the other places is at present imperfectly understood. The prospects of successful borings on the great mass of the Irrawaddy rocks which occupies the rest of the Pagan sub-division are poor. On the eastern edge of the riverine water-bearing area there are chances of obtaining water at depth from the "water-table" of the Irrawaddy River. If trial borings are successful water might be pumped to some of the villages in the "dry" tract, lying within reasonable distances.

Kyaukpadaung sub-division.

The Kyaukpadaung waterless tracts total nearly 200 square miles and contain many large and important villages. One area of 150 square miles is a southerly continuation of the Pagan waterless tract, the other of 50 square miles bounds it on the east. False-bedded sands of the Irrawaddy series cover both parts and boring for water anywhere in them is very speculative. As the areas lie within comparatively short distances of Mount Popa, from which many excellent streams of water emerge, it may be possible to supply them more economically by this surface water than by risking deep borings in the Irrawadian.

Tube wells, Rangoon.

In 1893, Mr. R. D. Oldham reported on the alluvial deposits and subterranean water supply of Rangoon (*Rec. Geol. Surv. Ind.*, Vol. XXVI, pp. 64—70). The number of tube wells drawing water from the strata underlying Rangoon and its environs to-day, is very much larger than it was at that time and these sources of excellent water are now relied upon to supplement the normal supplies of the city. Soon after

his arrival in Burma, Dr. J. Coggin Brown during the summer of 1926 took up the study of the underground water supply of Rangoon. He was impressed by the fact that very little is known regarding the sources of this water or of the conditions under which it exists, and he believed that there were good grounds for the suspicion that excessive drilling might result in the wholesale contamination of certain wells. Certain curious anomalies in the distribution of the deeper water-bearing gravels exist, which have resulted in the loss of large sums of money expended on dry bores. These anomalies could doubtless be explained on geological grounds if full records were available, and steps could then be taken to avoid such evil results in future.

It was soon found that the collection of the essential data was practically impossible. In many cases no records or samples of the strata passed through are extant neither are the owners or drillers of these water wells under any obligation to supply information concerning them, if they do not desire to do so. The thanks of the Geological Survey of India are all the more due to those Government officials, public bodies and private individuals who have supplied such records as they possess, though unfortunately these records are neither complete nor numerous enough to form the basis of a thorough investigation into the subject at present.

A draft Bill to control and regulate the supply of underground water has been drawn up in the Department concerned, with the technical assistance of the Water and Sewerage Engineer to the Public Works Department and of the Superintendent of the Burma Party of the Geological Survey and will doubtless be considered by the Government of Burma in due course. All that can be done at present is to collect information as opportunity offers and to encourage drillers to keep proper logs and send samples to the sub-office of the Geological Survey of India in Rangoon for determination and record. Progress is being made in these directions but it is slow.

Rangoon water supply schemes.

Closely interwoven with the question of the underground water of Rangoon is that of the surface supply, which satisfies by far the greater part of the city's needs. Owing to the continual growth of the population and the opening up of new residential areas in the environs, the present water supply is barely sufficient and the question of increasing it has engaged the attention of the authorities for some time. Mr. B. Raikes has submitted two alternative schemes

for augmenting the present supplies, known respectively as the Yomah and Yunzalin schemes. The geological aspects of the latter were studied by Mr. E. L. G. Clegg whose conclusions form an appendix to Mr. Raikes report. During the year under review, the Local Government requested that a detailed geological survey of the various Yoma sites might form part of the programme for field season 1926-27. At a later date, however, the Yoma project was abandoned for the time being and representatives of a well-known firm of consulting engineers arrived in Burma to study the Yunzalin scheme on the spot. This is a combined hydro-electric power and water-supply project which although very costly is believed to be large enough to free Rangoon from any possibility of water shortage for many years to come. As the original scheme has been entirely remodelled and several new features introduced, the Local Government requested that a fresh geological examination of the area might be made. Mr. E. J. Bradshaw left to undertake this early in December 1926. The question of the liability of the Yunzalin dams to damage during earthquake shocks formed the subject of a note by Dr. Coggin Brown.

Tube-well water supply for Thazi, Upper Burma.

Regarding the question of a tube well water supply for the town of Thazi, an important junction on the main line of the Burma Railways, 80 miles south of Mandalay, Dr. Coggin Brown pointed out that the prospect of obtaining potable water within reasonable depths in the Tertiary rocks on which the town lies, is so slight that it could be ruled out of consideration. He has suggested that the best chances lie in the alluvial valley of the Samon River which lies between Thazi and the edge of the Shan plateau.

The ground was examined by Mr. C. T. Barber, early in October, on his return journey from Mount Popa to Rangoon. His traverses proved an entire absence of exposures, though he was able to glean a certain amount of information by a detailed study of 39 existing shallow wells. The majority of the wells in Thazi itself fail at the commencement of the dry season, but in a belt passing through the villages of Zibinbauk and Aungtha, a perennial supply is obtainable at shallow depths. East of this zone, as far as Mezali, the wells go dry in the summer.

Mr. Barber recommended that a shallow trial boring be put down in the Zinbinbauk-Aungtha belt, and the behaviour of the supply under continued pumping carefully studied, for, while the wells

at present existing there are perennial, it must be remembered that the volume of water extracted from them is small. If this test fail, a deep trial boring should be made between Pomezagon and the Samon River. If the shallow test in the Zibinbauk-Aungtha zone yield favourable results, it may be found more economical to extract water there from such shallow depths by means of " spear pumps " than by sinking additional tube-wells.

The vexed question of an adequate water-supply for the town of Amraoti in the Central Provinces was again referred to the Geological Survey of India, and the investigation of a gravity supply was entrusted to Mr. H. Crookshank.

Amraoti : Central Provinces.

The public water-supply of Amraoti city and camp is at present derived from two tanks and a number of wells. Owing to low rainfall and inadequate catchment areas, the tanks are rarely filled, but they are fairly water-tight, and when an exceptional downpour fills them, greatly assist the city supply. Such leakage as does occur finds its way back into wells and is not altogether lost; this is proved by the fact that many of the wells go dry at the same time as the tanks.

Supplies from these sources have been insufficient in the past, and the position is yearly becoming more acute owing to an increasing population and a gradually decreasing rainfall. Either the city must cease to develop or some fresh source of supply must be discovered.

New wells have been sunk, but the amount of water so obtained has not greatly affected the situation. Schemes for pumping from the adjacent river beds have been rejected on account of their high running expenses, and it was decided to investigate the possibilities of a gravitation scheme.

For such a scheme there are two possible sources of supply, the Purna and the Maru rivers. Both these rivers rise in the Gawilgarh hills and flow in a southerly direction towards the plain of Berar. The Public Works Department have selected a number of possible dam sites where these rivers debouch from the hills, and have asked for assistance in deciding which of them is the most advantageous.

Above the proposed dam sites on the Purna river, Mr. Crookshank reports, there is a large catchment area in precipitous

country, where the annual rainfall is over 40 inches and where the rocks are almost impervious. Consequently there should be a yearly run-off greatly in excess of Amraoti's present or future needs. This is a point, however, on which the engineers should satisfy themselves before commencing work on any of the gravitation schemes. The above remarks are equally applicable to the Maru river, where the catchment area is even greater than that on the Purna.

On the completion of a reservoir at one or other of the proposed sites it is suggested that water should be brought to Amraoti by pipe-line. The cost of a reservoir and pipe-line from either the Purna or the Maru will be very high, but it is believed that the population would double itself in 10 years time if a good water supply were assured. In these circumstances a big expenditure is perhaps justifiable. By far the biggest item in the total cost will be the pipe-line, which would have to be about 35 miles long for the Purna river scheme, and about 45 miles for that of the Maru. Mr. Crookshank, however, is of opinion that the expense on this account would be greatly reduced if an open canal could be used to bring the water from the main storage reservoir to a smaller one (probably one of the existing tanks) near Amraoti. Such canals are extensively used to carry water across similar cotton-soil plains both in Bombay and in the Central Provinces. Accurate information on the water lost in transit by canal could doubtless be obtained from the Irrigation Departments in these provinces, and the comparison of the advantages of an open canal or a closed pipe-line would then be possible.

On the stretch of the Purna river, where it is proposed to build a dam, all the rocks belong to the Deccan Trap series. They consist of three basalt flows separated by Intertrappean zones. All these rocks have a southerly dip just less than the river gradient. Hence it is to be expected that the river bed will lie in a single flow for a long distance, but will ultimately cut its way into a lower one. Actually the river bed lies in the middle of the three flows from just south of site No. 1 to well below site No. 4 except for a few short distances where it has not yet cut through the hard base of the upper flow (*see* fig. 1). Half-a-mile south of site No. 4 the river finally cuts through the middle flow and thereafter runs in the lower flow.

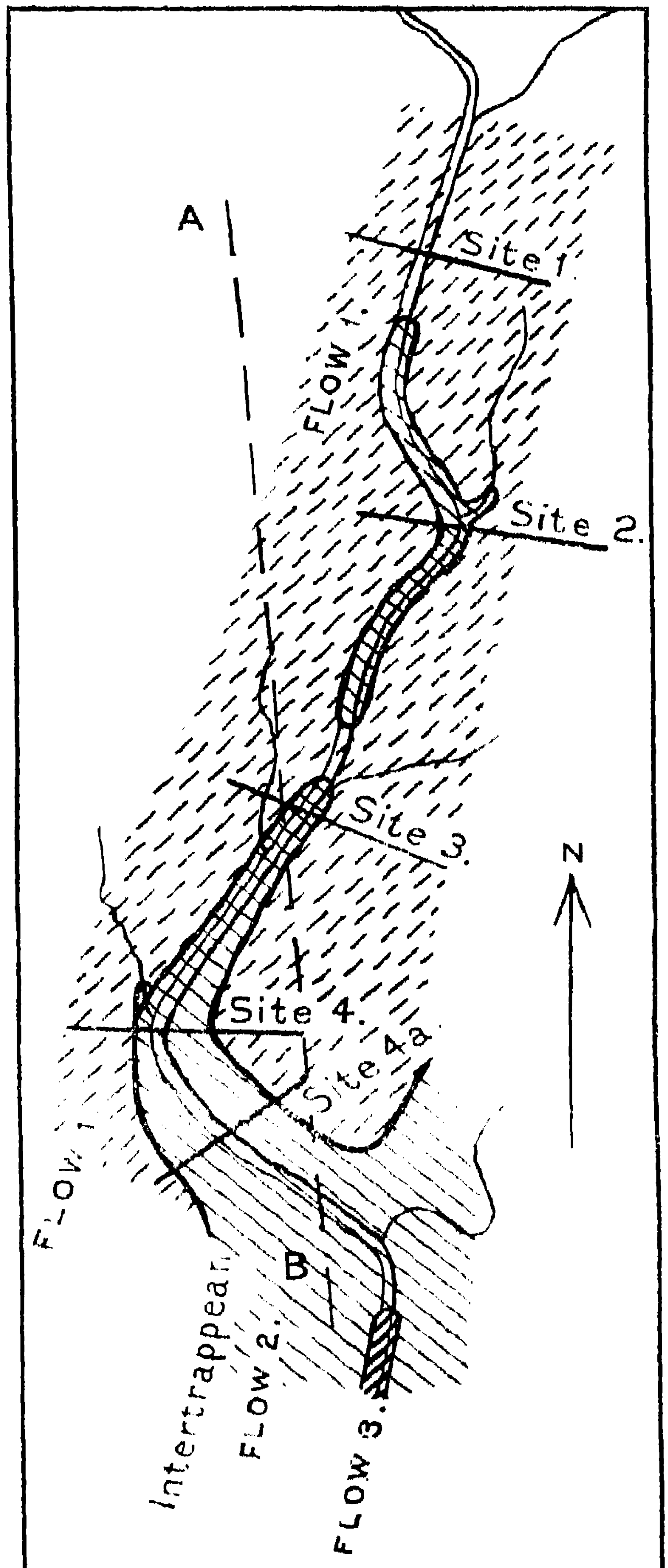

FIG. 1.—Purna River dam-sites (scale 1 inch = 1 mile).

All three flows are described as hard and impervious except at their upper and lower surfaces; here they are somewhat porous, but probably not more so than other trap flows. They are also much jointed, but experience in other localities proves that these joints are too tight to allow water to percolate freely, and that they tend in course of time to become water-tight owing to the deposition of silt.

The Intertrappean zone separating the upper and middle flows is a well-marked feature, and probably very thick in places. It is composed of angular and rounded fragments of basalt in a zeolitic matrix, and may represent debris deposited by some river before the extrusion of the upper flow. Whatever its origin may be, there is no doubt that it is highly porous and allows water to pass freely. Hence the springs and seepages which may be seen at intervals the whole way from site No. 4 to just below site No. 1. This Intertrappean zone is much thicker than is usual in the Deccan Trap, and is undoubtedly the weak spot in the Purna river schemes.

Mr. Crookshank thinks there is danger that water at a high pressure would pass rapidly through this zone, and would escape around the flanks of any dam. If the height of the dam were increased the storage would probably increase more rapidly than the leakage, but a point would be reached where the velocity of the water forced through the crevices in the Intertrappean bed would be so great that it would not deposit its load of silt. In this case the crevices would be scoured out, and not silted up, as is the case when the velocity is small. For this reason Mr. Crookshank suggests that the high-water level should not be much higher than the base of the Intertrappean zone. This would only be possible in the case of dams of moderate height.

The scheme at present under consideration is to impound some 200 million cubic feet of water by building a dam about 80 feet high at site No. 3. Since, however, the Intertrappean outcrop is only a few feet above the river bed at site 3, it will be covered by some 60 to 70 feet of water when the dam is full. This is, in Mr. Crookshank's opinion, risky and the continuation of work at this spot is not advised.

Two alternative sites where leakage through the Intertrappean rocks would be less likely to occur are available. These

are site No. 1 and site No. 4a (a site somewhat further downstream than site 4).

A dam at site 1 would rest on the lower part of the upper flow, and would have its flanks in reasonably sound rock up to some 40 feet above the present river bed. About this level another Intertrappean zone is to be expected, but this is not likely to cause undue leakage if the dam be not a high one. Some loss may also be expected through the river bed, but this should soon be sealed up by the deposition of silt.

A dam at site 4a would rest on the lower part of the middle flow, and would have advantages similar to those at site 1. The exact height of the Intertrappean zone at site 4a could be ascertained by boring. It would in Mr. Crookshank's opinion be unwise to raise the dam more than 20 feet above that level.

Numbers 1 and 4 are thought to be reasonably good sites; a high dam could be avoided by building low dams at each of these places and by fully utilizing the present storage tanks at Amraoti. Incidental advantages of such a scheme would be that much of the leakage from the upper dam would reappear in the lower one and that the increased seepage from the Amraoti tanks would improve the city well water supply. Increasing demands for water could be met either by building further dams or by increasing the height of those already constructed.

If it be decided to make a reservoir on the Purna river, Mr. Crookshank recommends the construction preliminarily of a low dam at site 4a before any other work is undertaken. If this proved a success in its first year, it would improve with time and the remainder of the work could then be completed without any fear of failure.

With regard to the Maru river eight possible positions for a reservoir have been chosen on the stretch of the river lying between Salbardi and Sukua. The rocks of this locality are varied, and it has, therefore, been necessary to consider each dam site on its own merits.

Sites 1 and 2 have been rejected on administrative grounds (*see* fig. 2).

The rocks in the river bed at site 2a consist of massive sandstones and conglomerates of Upper Gondwana age. Above

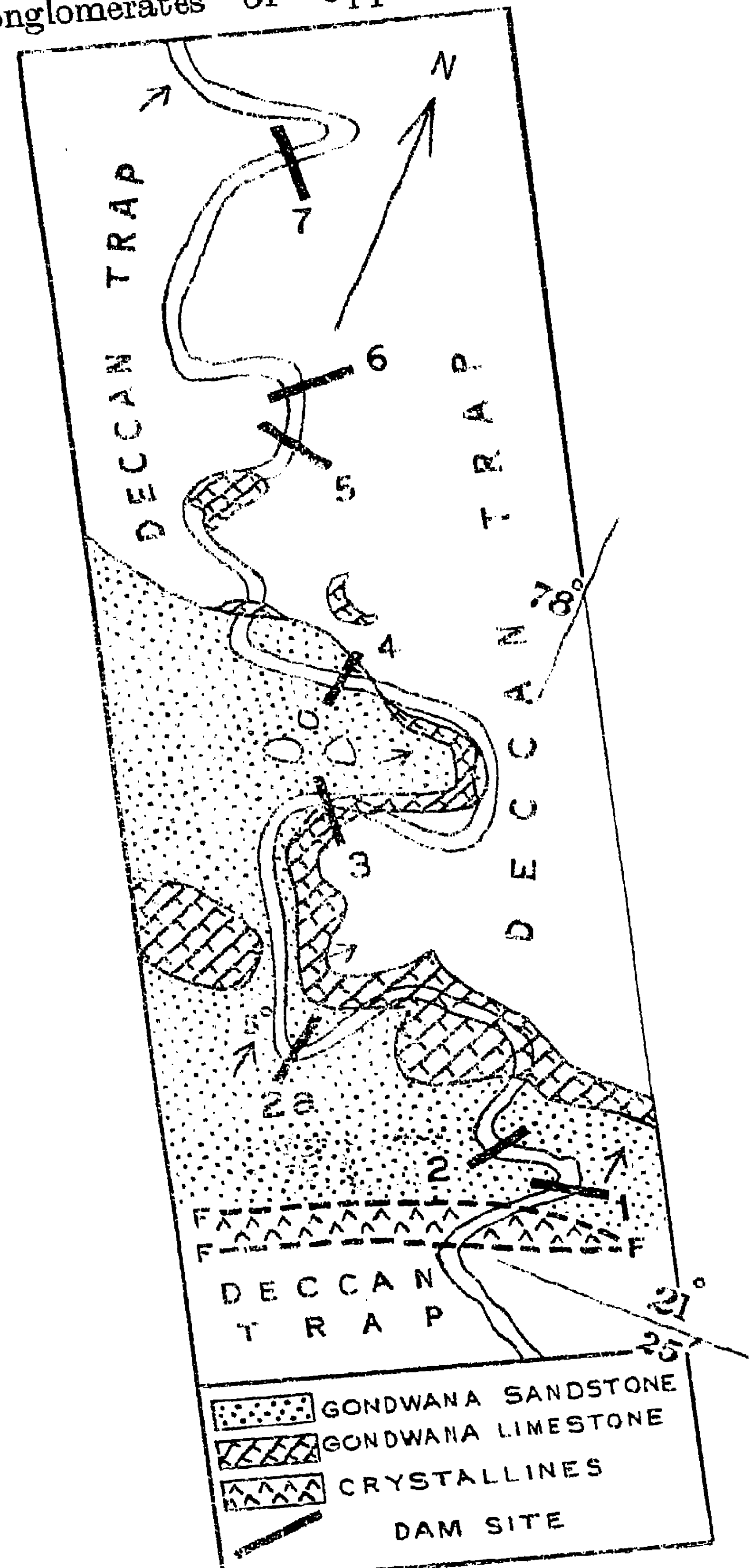

FIG. 2.—Maru River dam-sites (scale 1 inch = 1 mile).

these on the east bank of the river variegated sandstones followed by siliceous limestones occur. As a result of the important faulting along the boundary of these hills one mile further south, all the rocks about site 2a have a dip in a N. N. E. direction of about 15° S.

The sandstones and conglomerates which form the river bed and the southern side of the Maru valley at site 2a are massive somewhat porous rocks containing few fissures or joint planes. They should provide a good foundation for any dam designed with due regard to the upward pressure exerted by the water which will slowly percolate under the foundations when the dam is full.

The variegated sandstones seen in some places between the Gondwana sandstones and the overlying limestones were not noticed at the dam site, but they are nonetheless probably there. Elsewhere they were ill-consolidated, and contained numerous nodules of calcite. If present, they might cause a serious leakage, which would tend to increase rather than decrease owing to the solution of the lime in the rock by the percolating water. A boring through the limestone down to the underlying Gondwana sandstone is necessary in order to gauge properly the thickness, level, state of consolidation, and calcareous nature of these variegated sandstones.

The limestone is a highly siliceous rock sometimes amounting to a calcareous conglomerate. It is certainly non-porous, and does not appear to be fissured; it should, therefore, make a reliable northern flank for a dam. Overlying the limestone is impervious basalt, which would no doubt be a useful building material, but which is otherwise unimportant, as it is above the high-water level of any contemplated reservoir.

Owing to the porous nature of the rocks in the reservoir basin above site 2a, there will be a loss of water by absorption. There will also be a slow seepage under the dam and round its flanks.

Sites 3 and 4 are geologically similar to site 2a, but they are inferior from an engineering point of view.

Sites 5 and 6 are both situated entirely on rocks of the Deccan Trap series, which have an approximate dip of 8° in a direction N.E. Although basalt flows are to a large extent impervious, it is well known that their upper and lower surraces

are usually somewhat porous. The result of this is that a pervious zone of variable thickness is found at the junction of successive flows. Owing to the dip of the flows and the direction of the proposed dams, such pervious zones would cut across both No. 5 and No. 6 dam sites (*see* figure 2). Although these pervious zones may not cause any very serious leakage, they are weak spots which should be avoided if possible.

Site 7 is considered superior to 5 or 6; it has been chosen in a narrow gorge S. E. of Sukua. At this place the river runs between basalt, so that the geology is particularly clear. The cliffs are composed of thick basalt flows separated by thin porous Intertrappean zones, all dip at right angles to the direction of the proposed dam at about 5°. The result of this is that any water which leaks away through the Intertrappean zones will have to be forced to a considerable height before it can escape.

The basalt flows at site 7 are massive and impervious and should be strong enough to take the weight of any dam. Columnar basalt occurs at the river bend just above the dam site, and should provide an unlimited supply of easily quarried stone suitable for any heavy construction. In Mr. Crookshank's opinion this is as good a dam site as could be found anywhere in the Deccan Trap. It is, however, not greatly favoured by the survey party, partly on account of its inaccessibility, and partly because the basin above is believed to be small. Its inaccessibility is admitted, but all the proposed dam sites on the Maru suffer more or less from this defect. The basin above has not yet been properly surveyed, and may prove to be larger than was expected.

All the Maru river projects are likely to prove considerably more expensive than those of the Purna river. The chief reason for this is the length of lead to Amraoti, but there will also be serious extra expense owing to the difficult country over which a service road to any of the Maru dam sites must pass. Schemes 2a, 3 and 4 are at a further disadvantage in that the head will be too small to drive water down the proposed pipe-line to Amraoti. The advantages on the other hand are that the water impounded by any of the dams on the Maru would be three or four times as much as could be provided by a reservoir on the Purna.

Mr. Crookshank remarks that the cost of the Maru river schemes might be lessened by selling the surplus water or by leading the water in an open canal from the river to a storage tank near the city; this would probably not be possible in the case of the Purna river, as the storage there would be small and any waste in transit would be serious. If a canal be possible, a reservoir at either site 2a or site 7, on the Maru is suggested as the most suitable. The latter site is thought to be in every way preferable if the storage basin above it is comparable with that at site 2a. If a canal be not possible, Mr. Crookshank would give the Purna river a fair trial by building a dam at site 4a as suggested. If this were not a success, it would still be possible to return to the Maru river.

During the early part of the month of July, Mr. Gee was deputed to Jubbulpore, to advise on the tube-wells which were being put down in the Gun Carriage Factory for the requirements of the factory and the connected residential quarters.

Jubbulpore : Central Provinces.

From Dr. C. A. Matley's 8-inch map of the area and from observations made on the spot it was seen that a N.E.-S.W. fault passes through the factory bringing the Jubbulpore clays and sandstones against Lameta beds on the south. These Jubbulpore beds rest unconformably on the metamorphics which form the highlands to the north, and since they dip gently towards the Factory fault, one would expect the underground drainage to flow towards the fault. At the fault the Lameta clays should form an underground dam, and thus cause the accumulation of water on the north side of the fault. In these circumstances it was anticipated that a well sunk on the northern side of the fault would yield a good constant supply.

A tube-well, 6 inches in diameter, had been put down on a site selected by Major Pogson, a water-diviner, to the north of the fault, about 40 yards to the south-east of the north central gate of the factory. It had gone to a depth of 180 feet, having passed through the following strata:—

1	34 ft.	Sand and earth.
2	34—119 ft.	White and grey sandstones, the lower types coarse-textured and very porous.

3	119—132 ft.	Hard impervious clay.
4	132—135½ ft.	A fine brown ferruginous loose sand, including irregular boulders of hard porous grit.
5	135½—180 ft.	Metamorphics.

The massive unjointed metamorphics having been encountered, Mr. Gee considered that further boring was useless, and suggested that as the lower sandstones are capable of holding large quantities of water, while the unconsolidated boulder-bed at the base of the sedimentaries should allow a free accumulation and circulation of water under semi-artesian conditions, a careful test should be run to prove the capacity of the well. As a site for a further boring he selected a point on the Jubbulpore clays just to the north of the fault, not far from the main western gate of the factory. The conditions should be very similar to the tube-well already made.

Kurram Valley, North West Frontier.

Dr. Cotter was requested to report on the prospects of artesian water near Kharlachi village about eight miles west of Parachinar. Owing to the preponderance of gravel and the absence of any impervious stratum of clay in the alluvial deposits near the village, he does not consider that water under artesian pressure is likely to be found. He recommends the construction of a trial bore near Kharlachi village, but anticipates that the water if found will not rise to the surface, but will have to be raised by mechanical means. The construction of a *karez* near Kharlachi post and perhaps near Burki village is also suggested.

Kot Fateh Khan: Punjab.

Towards the end of field-season 1925-26, Sub-Assistant H. M. Lahiri examined the area of Kot Fateh Khan (33° 32′ 20″; 72° 30′ 20″) in connection with the question of water supply for the purpose of irrigating a tract of land to the east of the town, where it is proposed to start an agricultural farm for demonstration purposes.

The tract consists entirely of alluvial clay with calcareous nodules in places. Outcrops of Murree rocks occur to the south-east and west of the tract. The Murrees consist chiefly of soft greenish or pepper-and-salt sandstone with some pseudo-conglomerate and purple shale. The beds have an average dip of 60° and form the southern limb of a syncline.

Of the two streams that join near the village, the Dotal Kas alone has perennially running water. The water-table of the area coincides practically with the bed of this stream. The people of the locality get their supply of drinking water from small shallow pits dug in the stream-bed and utilise the running water for other domestic purposes. The stream immediately to the east of Kot Fateh Khan has no running water in it. This has, however, been dammed near its junction with the Dotal Kas and the water that collects here during the Rains is utilised chiefly for irrigating one of the Sirdar Sahib's gardens.

There are several large dug wells in and near the village, the majority of which are situated on the bank of the Dotal Kas. The water level in the wells is roughly about 30 feet from the land surface. The wells along the Dotal bank have an average total depth of about 50 feet and throughout their entire depth they pass through alluvium only. These wells are worked by "Persian wheels" and yield a good supply of water.

There are three wells in the village proper, one of which is about 50 feet deep and yields a satisfactory supply of water for drinking purposes. Like those along the Dotal bank this well is entirely in alluvium. In another well, however, only ½ furlong S. of the former, there is practically no seepage of water. In this, according to report, purple shale was struck after about 20 feet of surface alluvium. Digging is said to have been continued for about 20 feet further down in the shale but whatever little water there is in this well, is slightly brackish to the taste. Advice was given as to where a new well would be likely to encounter a good supply of water attainable by a pump worked either by a windmill or by a crude oil engine.

Rawalpindi district: Punjab.

In response to an inquiry by the Development Department, Punjab, regarding four proposed Artesian well-borings in Rawalpindi district, Mr. Wadia reports that the problem of ground-water in most parts of the Rawalpindi plateau is essentially concerned with its superficial alluvium and hardly touches its solid geology. He does not think that hidden ridges of the Eocene limestone under any and every anticline of this area are the sources of all well-water in Rawalpindi.

Artesian and semi-artesian conditions, however, do exist in the Sub-Recent gravelly drift which caps the Rawalpindi plateau.

These gravels are fed by water-courses descending the sub-montane Margala slope, the water being carried underground until its further southward journey is intersected by N. W.'ly dipping transversely lying Murree ridges.

The Khanna area, with its 4 or 5 existing flowing wells, is a true artesian basin, whose southern wall is the Chirpar ridge of Murree sandstones, mostly concealed here under the alluvium. It is this ridge which checks the downward course of the water and forces it up to about 14 feet above the general level of the surface.

A second set of "Artesian" conditions arises where portions of the high gravel-seamed plateau and hog's-back subsidiary water-divides fall away in steep *khudderas.* In these trenched parts of the plateau numerous springs representing the drainage of the high ground, arise. Wells in these situations would tap water under artesian and semi-artesian conditions, while wells bored in the more central parts of the plateau are generally deep and dry.

Mr. Wadia recommends carrying the bores at the Usman Khatter and Karmwal sites a hundred feet deeper than the maximum depths of 200 and 300 feet originally proposed for these borings.

GEOLOGICAL SURVEYS.

Bihar and Orissa.

During the field season, 1925-26, the Bihar and Orissa party consisted of Mr. H. Cecil Jones (in charge), Dr. J. A. Dunn, Dr. M. S. Krishnan and Sub-Assistant L. A. Narayana Iyer.

Mr. Jones continued the systematic geological survey of the iron ore area in the south of the Singhbhum district, and in the adjoining Feudatory States of Bonai and Keonjhar and worked on the Bihar and Orissa standard sheets Nos. 73 $\frac{F}{4}$ $\frac{F}{8}$ $\frac{G}{1}$ and $\frac{G}{5}$. The geology of the area surveyed was very similar to that described in previous general reports, and the Iron Ore series covers most of the ground examined. The granitic outcrop which occurs to the south-west of the older Dharwar rocks and the Iron Ore series was reached, and a portion of its boundary in Bonai State was mapped. This granitic rock is intrusive into the older Dharwar rocks and the Iron Ore series, and is very similar to the granitic mass which occurs near Chaibassa. It is of an acid type, and like the Chaibassa

mass is cut up by a series of ramifying basic dykes, and by dyke-like masses of ultra-basic rock. The basic dykes vary from dolerite to basalt, and the ultra-basic rock which is usually very much altered to serpentine, was originally a peridotite.

In the south-western part of the area investigated is a series of sandstones, often coarse-grained and conglomeratic, which have in general a different appearance and newer aspect than anything noted in the older Dharwars or in the Iron Ore series. In places these sandstones appear to be unconformable to the older rocks, but in other places they appear to be interbedded with the Iron Ore series. This apparent interbedding may be due to folding, and Mr. Jones hopes to settle the age of these rocks during the coming camp season. Mr. F. E. Smith, late Assistant Superintendent of this Department, has recorded some patches of Cuddapah rocks near this point, and the sandstones noted by Mr. Jones may prove to be of Cuddapah age.

During the season Mr. Jones inspected the prospecting and boring work being done by the Tata Iron and Steel Company in their Noamundi mine area near Jamda (22° 09′ : 85° 25′). During the sinking of a prospecting pit in this area the coolies, after opening up to a depth of about fifteen feet, suddenly broke through to an underground cave. The cave was about four feet high, but owing to the narrowing down in height of the cave, the distance to which it extended was not determined. This occurrence of underground caves is a possible explanation of the hollow sound that is often noted when walking over some parts of the iron ore area. The pit was put down in a ferruginous lateritic material, and an analysis of this material from the bottom of the pit, made by the Tata Iron and Steel Company showed that it contains 30·5 per cent. of $CaCO_3$, the solution of which evidently accounts for the cavity. There appears to have been a narrow band with a high percentage of lime ; the surrounding laterite shows a normal constitution on analysis.

Ranchi district: Bihar and Orissa.

From December to March Dr. Dunn worked in the Ranchi district on Survey Sheets 73 $\frac{F}{1}$ $\frac{F}{2}$ and $\frac{F}{5}$ in order to complete his investigations of the previous four seasons. The Iron Ore series is reported to be the same suite of metamorphic rocks as previously described. In the most north-westerly part of the metamorphic area, isoclinal

folding, indicated by the innumerable bands of the metamorphosed Dalma volcanics, becomes more acute than in any other part of the area. The rocks here are also amongst the most highly metamorphosed, and the hornblende schists alter in places to hornblende-kyanite-sillimanite rocks and kyanite-sillimanite-garnet rocks. The only new feature is the Chota Nagpur granite-gneiss. This is part of the enormous outcrop of granite-gneisses and schists stretching east and west across Bihar and Orissa from Bengal to the Central Provinces with a N.-to-S. width of over 120 miles, and which by the early surveys was regarded as the Fundamental Gneiss. It appears, however, to be intrusive into the Iron Ore series, and Mr. Dunn regards it as the more highly metamorphosed equivalent of the Singhbhum and Chakradharpur granitic rocks. The rock varies considerably in texture from a fine-grained microgranite-gneiss through a typical granite-gneiss to a pegmatite, the age—older to younger—being as a rule in that order ; all are, however, within the one period of intrusion. There is also every gradation from a rather basic rock to pure quartz. Shearing has, in places—particularly near the boundary—given rise to typical wood-gneisses, or granite-schists.

The rock is full of inclusions of both mica schists and hornblende schists, and the intrusion in places is described as having been more of the nature of a *lit-par-lit* injection. Occasionally the effect of these inclusions has been the production of hybrid types the mode of formation of which may be clearly noted in the field.

The linear arrangement of the ferro-magnesians in the gneissic granite Dr. Dunn does not regard as due directly to pressure, but thinks that this linear arrangement took place as the ferro-magnesians were crystallising out, whilst the magma was still molten, in such a liquid pressures being hydrostatic. The wider bands of acid and basic granite-gneiss are regarded as the later squeezing effect of pressure on the magma at the period when it reaches the consistency of a sponge during crystallization.

The area covered by Dr. Krishnan is contained in sheets $73\frac{F}{12}$ and $73\frac{F}{8}$, and also includes about 35 square miles along the northern edge of sheet $73\frac{G}{5}$, all to the scale of one-inch-to-a-mile.

Keonjhar, Bihar and Orissa.

A traverse through the Kolhan Government Estate of Singhbhum district, from Chaibassa to Jamda, which occupied about three weeks in November, 1925 proved a useful introduction to the geology

of Keonjhar. The following geological sequence has been established in the latter State :—

Dolerite (as intrusive sheets and dykes).	
Eruptive contact.	
Granite and Granite-gneiss (intrusive).	
Eruptive contact.	
Purple shales (upper)	Iron Ore series.
Banded hæmatite-quartzites, with iron ore	
Purple shales (lower)	
Purple sandstones with bands of conglomerate	
Hornblende and mica-schists	older Dharwars.

The older Dharwar rocks are composed of highly folded and metamorphosed hornblende and mica-schists and quartzites ; these are the oldest rocks here. They are followed by beds of the Iron Ore series lying over them unconformably. These beds consist of a series of purple sandstones with conglomerates at the base, overlain by purple shales, banded hæmatite quartzites, and again Purple shales, in this order. The Dharwar schists occupy the middle portion of sheet 73 $\frac{F}{1}$ and the Iron Ore series is found to the west of them. The Granites, which are much younger than the above-mentioned rocks, occur as intrusions into them, particularly near the eastern edge of sheet 73 $\frac{F}{1}$. The youngest rocks of all are the sheets and dykes of dolerite occurring mainly to the west and north-west of the Dharwar rocks, but also in other localities.

Petrographically there is nothing very remarkable in the rocks, particularly in the mica and hornblende schists of the Dharwar system. The granite usually belongs to a very acid type (*e.g.*, near Sosang, 22°0′45″ ; 85°40′—slide No. 16799) and includes some micropegmatites. The dolerites frequently grade into basalts. A peculiarity with some of these, especially when occurring as dykes in granites, is the tendency to develop a micropegmatitic or granophyric structure around some of the well formed crystals of felspar. This is considered to be due to admixture with granite through which the dykes have forced their way up to the surface.

In the Iron Ore series the sandstones at the base are purple in colour, and sometimes enclose bands of conglomerate with jasper and quartz pebbles. Occasionally they include quartzites also. The shales above and below the banded hæmatite quartzite are soft and usually plastic. They are occasionally calcareous but no limestone bands have so far been observed in Keonjhar. The metamorphism

and hardening have not proceeded far enough to produce phyllites which seem to be so common in north Singhbhum. All the rocks of the Iron Ore series have a general dip to the W. N. W. or N. W. at 30° to 60°.

The banded hæmatite quartzites give considerable evidence of folding, and in two localities of faulting also. The first, a strike fault, is found along the Kundra Nala west of Joda (22°1′ ; 85°25′30″), and the second, which is an oblique one, occurs about a mile-and-a-half further to the N. W. The downthrow is to the S. E. in both cases. The minute crumpling, exceedingly well developed even in hand-specimens, is probably due to pressures set up during the process of replacement of the siliceous bands by hydrated ferric oxide.

This region contains a number of good deposits of iron ore, derived, it is thought, from the metasomatic replacement of the banded hæmatite quartzite by hydrated iron oxide through the agency of downward percolating waters. There are, in addition, a few cases of iron ore resulting by a process of segregation from the purple shales. This latter class of ore is frequently associated with manganese.

Ranchi and Singhbhum districts : Bihar and Orissa.

During the field season, 1925-26, Sub-Assistant L. A. Narayana Iyer worked in both the Ranchi and Singhbhum districts. The work in the Ranchi district was in continuation of the work done with Dr. J. A. Dunn in the Porahat Estate during the previous field-season and comprised Survey Sheets 73 $\frac{F}{1}$, $\frac{F}{2}$, $\frac{F}{3}$, $\frac{F}{5}$, and 73 $\frac{F}{14}$, $\frac{F}{15}$ and $\frac{F}{16}$.

With the addition of gneiss the geological formations encountered were the same as those found previously. From the southernmost boundary in the Ranchi district, the progressive metamorphism of the phyllites and mica schists assigned to the Iron Ore series was noted ; with them were seen a large number of bands of hornblende schist alternating with the mica schists, a result of the very acute folding. These are followed by the Ranchi Granite Gneiss, which is clearly intrusive into the rocks of the Iron Ore series..

Mr. Iyer describes the Granite Gneiss as forming a huge batholith carrying a large number of inclusions of hornblende and mica schists and constituting in this area the marginal "shatter zone." The mica schist occurs in thin parallel bands, but the hornblende schist has been very much broken up in places, and somewhat

digested by the Granite Gneiss with the production of new minerals and hybrid rocks. A vermicular intergrowth of quartz and plagioclase, similar to Sederholm's "myrmekite" was observed by Mr. Iyer and the rocks and the structures bear a resemblance to those of Fennoscandia described by Sederholm.

The granite varies from place to place and consists of a number of types, *e.g.*, holocrystalline coarse grained gneisses, finer-grained gneisses, porphyritic gneisses with large porphyroblasts of felspar, pegmatites, microgranites, aplites and some sheared gneisses.

Burma.

During the 1925-26 field-season the Burma Party of the Geological Survey of India consisted of Dr. J. Coggin Brown, in charge, Messrs. E. L. G. Clegg, C. T. Barber, and P. Leicester and Sub-Assistant B. B. Gupta.

As part of the Amherst district has been recently surveyed topographically on the 1 inch=1 mile scale, a systematic geological survey is now possible. This will eventually link up with the areas already completed in Tavoy, and elucidate the distribution and causes of the mineralisation which is known to have taken place during the epoch of the granite intrusion. With this end in view Dr. Brown made a preliminary traverse through the southern portion of the Thaton district and as many of the surveyed sheets of the Amherst district further south as time allowed, in order to decide where methodical work should be commenced. Although the two districts are separated politically, they form part of the same geological province, as, indeed, do the more southerly ones still, Tavoy and Mergui.

The only earlier survey in the Thaton district was carried out by Mr. P. N. Datta, who spent part of the field-season 1908-09 in mapping portions of sheets Nos. 307, 353, 354, 355, 356 and 403. His results are referred to in the General Report of the Department for 1909 (*Rec. Geol. Surv. Ind.*, vol. XL, pp. 107 and 108). The surveyed area comprises a strip of the hilly country running in a south-easterly direction parallel to the Rangoon-Moulmein railway from about where it crosses the Sittang River to its terminus on the north bank of the Salween at Martaban.

W. Theobald's map of 1873 just crosses the Sittang and on its eastern bank he shows the edge of his Martaban Group. In this group Theobald included both gneisses and granites; "petrologically considered" he wrote, "it is a group of true crystalline rocks,

undistinguishable in character from the ordinary gneissose rocks of Bengal," though he had no hesitation in referring much of the so-termed granite of the country lying to the east of the Salween to this group. He admitted that true granite undoubtedly occurs in the district in the shape of granite dykes which traverse beds referred by him to the "Moulmein" group, but no conclusive evidence had yet been produced that the largely developed granitoid rock of "Kyoukyee," "Kyiktyo," etc., was really intrusive, and till that was produced he did not consider its mere lithological aspect as sufficient for the purpose.[1]

With our better acquaintance with the Tenasserim division, we now know, that the Martaban group consists of two series of crystalline rocks of vastly different ages, one an ancient series of typical Archæan gneisses and the other an intrusive granite of very much younger age. As a result of this season's work, Dr. Brown came to the conclusion that the Thaton granite was intruded in at least post-Permian and probably post-Triassic times. He believes that the Thaton granite is identical in composition, age and mineral association with the major granite intrusions which stretch from Mergui into the hilly eastern edges of the Yamethin and Kyaukse districts; it would follow, therefore, that these are all of the same age, and comparable with the granites of British Malaya, Sumatra, Borneo and the Dutch East Indies.

Theobald had suggested long ago that the granites were post-Carboniferous. "It is probable," he wrote, "that this group (the Moulmein group) may prove to be metalliferous, as it is traversed by the same series of granite and elvan dykes, as the older crystalline rocks of the district; and these may not improbably be connected with the development of the ores of tin, lead, iron, and copper occurring in Martaban."[1] As Theobald gave no descriptions of his observations, nor mentioned the places where they were made, and as the methodical survey of Tavoy and Mergui yielded no evidence of the age of the granite, his suggestion was not regarded as definite proof.

Dr. Coggin Brown's work in 1906 had shown that the rocks in the vicinity of Sittang (17° 27′ : 19° 55′ 30″) and Myaungyaung

[1] W. Theobald. "Geology of Pegu," *Mem. Geol. Surv. Ind.*, Vol. X, Pt. II, pp. 139-140 (1873).

(17° 25′ 30″ 96° 56′) were true gneisses. It remained for Mr. Datta to map their boundaries, which are not extensive, and to prove that the great mass of the highlands further east culminating in Chaiteo H. S. (17° 29′ : 97° 8′), 3,617 feet above the sea, is built of truelyntrusive by biotite granite, as is also Kelatha Hill, some 5 miles to the south-east of Kyaikto, and close to the railway station of Taungzun.

In addition to the gneisses and granites Mr. Datta mapped a series of sandstones and shales, more or less metamorphosed in places, which extends from Martaban (16° 31′ : 97° 39′ 30″) to latitude 17°15′, beyond which it has not been followed. Its continuity is broken for a mile or two, some 8 or 9 miles from its southern termination by the intrusive Kalamataung granite *massif*, rising to a height of 3,025 feet above sea level.

From the shales of this series near Martaban itself Mr. Datta obtained fragmentary plant remains, bivalves, casts of what appear to be *Orbiculoidea* and wings of insects, probably belonging to a Palæozoic representative of the *Orthoptera*. He did not regard these organic remains as sufficient to indicate the age of the shales, though he concluded, provisionally, that the shales and sandstones of the Thaton district probably belong to the "Moulmein" group of Dr. Oldham and are referable to the Carboniferous period.

In 1921, Prof. J. W. Gregory re-discovered Mr. Datta's fossil-bearing locality where he describes the occurrence of a black shale or mudstone, interbedded with a brown-weathering quartzitic grit; the beds dip at 30° to 10°N. of E. Prof. Gregory was fortunate in being able to have identified by Mr. J. Weir the bivalves which Mr. Datta had noticed 14 years before[1]. These proved to be *Palæonodonta okensis* (Amalitsky) and *Palæonodonta subcastor* (Amalitsky).

According to Amalitsky, *P. okensis* occurs in the Permian marl and sandstones of Nishny-Novgorod while P. *subcastor* is found on all the horizons of the Permian marl and sandstones of eastern Russia. Both species occur at Graaff Reinet in South Africa.[2] The genus was founded by Amalitsky to include the toothless forms of the *Anthracosidæ* previously grouped under *Naiadites* (Dawson) The family itself is confined to fluviatile and brackish formations

[1] J. W. Gregory. *Geol. Mag*, Vol. LX, p. 153 (1923).

[2] W. Amalitsky: "A Comparison of the Permian Fresh-water Lamellibranchiata from Russia with those from the Karoo System of South Africa." *Q. J. G. S.*, Vol. LI, pp. 347-348 (1895). E. Haug. "Traité de Géologie" p. 793.

of the Devonian, Carboniferous, Permian and Trias; the genus is restricted to the Carboniferous and Permian.[1]

With regard to the Russian beds in which various genera of the *Anthracosidæ* occur, Haug remarks that Permian limestones of the Volga basin gradually give place towards the west and north to variegated marls with a brackish fauna which is especially developed in the upper stage but may encroach upon the whole Permian. The marine fossils are then replaced by *Anthracosia*, *Carbonicola*, *Naiadites*, etc. According to Haug it is probable that the upper part of these marls and variegated clays already belong to the Trias. In the region of the headquarters of the Dvina, the upper Permian alone crops out and is exhibited as variegated marls with brackish-water molluscs (*Palæomutela*, *Palæonodonta*), intercalated between two beds with a marine fauna. Amalitsky found in the sandstone lenticles there entire skeletons of *Pareiosaurus*, *Dicynodon* and other reptiles, as well as impressions of *Callipteris*, *Glossopteris* and *Gangamopteris*. As Haug noticed there are remarkable analogies, therefore, with the Permian of the southern hemisphere.[2]

The Graaf Reinet locality is in the Beaufort Beds of South Africa, which form the middle division of the Karoo system and occupy almost the whole interior of the Cape Province, spreading over the adjoining parts of the Orange Free State and elsewhere. The lower and middle parts of the series indicate the Permian and the upper the Trias, according to Cowper Reed. Hatch and Corstorphine, however, state that they may be taken as representing the Trias. Many writers, place the Beaufort series in the Trias, but E. Haug regards it as more convenient to separate the lower part, in which the remains of *Pareiosaurus serridens* have been found. This genus occurring as we have seen in the uppermost Permian beds of Northern Russia, the same age may be attributed, at least provisionally, to the basal members of the Beaufort Beds. They also contain *Schizoneura* and *Glossopteris*.[3] Professor Gregory states definitely that the Martaban grits are of Permian age, but it appears to Dr. Brown from the evidence already given, that they might equally well be Triassic. Mr. Datta, who did not use the fossil evidence of the Martaban beds, believed that, as the few fragmentary organic remains

[1]Zittel. "Grundzuge der Paläontologie," I, p. 380 (1921).
[2] Traité de Géologie.
[3] "Geology of the British Empire," p. 98 (1921); "The Geology of South Africa," p. 344 (1909); *loc. cit.*, II, p. 815 (3rd edit.).

obtained from the shales at Martaban were not good enough to indicate what age the shales might belong to, all that could be provisionally said was that the shales and sandstones up till then surveyed in the Thaton district probably belonged to the Moulmein group of beds of Dr. Oldham and were referable to the Carboniferous period.

Dr. Coggin Brown's view is that they belong to a series of Permian or Permo-Triassic sandstones and shales which will eventually be found to overlie the limestones of the Moulmein Group.

Mr. Datta believed that the granite was intrusive into the sedimentaries, but, Dr. A. M. Heron, when investigating the wolfram and tin concessions of Southern Thaton in 1917, found pegmatites and quartz-vein dykes originating in the granite and penetrating for considerable distances into the sandstones and shales. After his traverse through southern Thaton this season, Dr. Brown is convinced that these sandstones and shales belong to the same group as the fossiliferous Martaban shales.

The questions as to whether this series covers the whole extent of the ground indicated by Mr. Datta and whether the phyllites and quartzites of the Thaton Range are upper Permian or Triassic in age, must be decided by further field work.

Dr. Brown made a large collection of the bivalves from Martaban and agrees with Mr. J. Weir as to their identification. With them were associated fragmentary plant remains. It is regrettable that Mr. Datta's collection cannot be traced in Calcutta, especially as his determination of *Orbiculoidea* needs confirmation.

Magwe district.

Mr. Clegg working in the Magwe district completed the northern unfinished portion of Sheets $84\frac{P}{12}$ and $\frac{P}{16}$ commenced by the late Captain F. W. Walker in the 1924-25 field-season. The area embraces the western slopes of the Pegu Yoma and the eastern part of the Taungdwingyi plain and includes rocks of the Pegu and Irrawadian series and alluvium. The Pegus consist of an alternating series of sandstones and shales, the latter, in which thin lenticular bands of limestone exhibiting cone-in-cone structure are frequent, occurring in increasing preponderance towards the Yoma watershed where the lowest rocks are exposed; broken marine fossils were found in the Kodu and Aungwin streams in isolated blocks. The Pegu series passes upwards and westwards through a soft fawn sandstone series, containing hard concretionary lenses, into Irrawadian beds characterised

by false-bedded fawn-coloured sandstones containing intercalated gravels and grits and with a soil cap enclosing small pieces of fossil wood and quartz and ferruginous pebbles. Towards the upper limit of the Irrawadian series, iron-stained and green mottle-weathered homogeneous sands are found; tubular and nodular sandy *kankar* concretions have penetrated these to a depth of more than 20 feet. The latter series passes imperceptibly into the alluvium of the Taungdwingyi plain. Minor folding and faulting is common in the area and the rocks of the various series grade imperceptibly one into the other. A curious point about the Pegu-Irrawadian boundary is the manner in which it coincides with the Government Reserved Forest boundary, the teak forest of the Sun and Sadon reserves being situated on Pegu rocks, whilst the dry porous Irrawadian series supports only prickly scrub jungle.

Yamethin, Meiktila, Kyaukse and Sagaing districts.

Mr. Clegg examined the range of hills west of the Rangoon-Mandalay Railway line in the districts of Yamethin, Meiktila, Kyaukse and Sagaing. They consist of Irrawadian and Pegu rocks, the former occurring from Yamethin (20° 26′; 96° 11′) to two miles beyond Ywatha (21° 27′; 96° 2′), whence inliers of Pegus continue in the Irrawadian to Tada-U (21° 49′; 95° 58′) and persist northwards on the western side of the Sagaing Hills, on the north bank of the Irrawaddy River. Where the Irrawadian beds are gently folded, the hills are flat-topped and occasionally crowned by quartz gravels, the latter formed by weathering *in situ*; fine sands, loosely cohesive and deeply mottle-weathered, are also exposed and two miles west-by-south of Ywapale (20° 55′; 96° 6′), teeth and broken limb-bones of one or two ruminants were collected. Red earth is common capping the hills and, south of Mogyodwin village (21° 36′; 95° 58′), a few species of fresh-water molluscs were collected in *kankar*-impregnated bluish clays. Where the dips are steep, false-bedded conglomerates form the peaks along the hill chain; they vary from fine sands with isolated quartz pebbles up to ½ inch in diameter, to coarse false-bedded conglomerates formed of aggregates of quartz boulders from 4 to 7 inches in diameter. The latter are very local and are included in the main series of conglomerates in which the diameter of the quartz pebbles varies from 1 inch to 4 inches and in which silicified fossil wood in lumps up to 11 inches in length are occasionally included. Many of the gravels have a ferruginous matrix; others are white from the kaolinisation of the felspar con-

stituent. West of Payapyu (21° 14′; 96° 1′), the conglomerate s cannot be less than 600 feet in thickness and is very reminis of the Irrawadian gravels south-west of Thayetmyo. The] rocks occur as inliers in the Irrawadian conglomerates and co in the southernmost inliers of soft fawn sandstones in which qu pebbles are conspicuously absent; they are all so fractured that bedding is not perceptible and is inextricably complicated by fa ing, shales in the series showing a maximum amount of slickensic The unconformity existing between the Irrawadian and the P is clearly seen in the more northerly inliers. The structure of hills as a whole is anticlinal but appears to consist of succes folding along slightly varying axes, later folding and faulting ha taken place at an acute angle to the earlier folding and given to the *en echelon* arrangement of the hills.

Sagaing and Lower Chindwin districts.

In the Sagaing district Mr. Clegg geologically surveyed parts of Sheets $84\frac{O}{9}$ and $\frac{O}{13}$ north of the Irrawaddy River and Sl $84\frac{O}{5}$ and $84\frac{N}{8}$, the latter of which is pa in the Lower Chindwin district. In the Sag Hills, Archæan rocks of the Mogok s are exposed as a series of quartz and biotite gneisses and sch and occasional hornblende gneisses, the whole being banded quartz veins and crystalline limestones; the latter give rise to ri which, east of Sagaing (21° 53′; 95° 59′), are crowned by whitewa pagodas and make the approach to Sagaing so picturesque. U Tertiary rocks lie unconformably on the crystallines, the r recent overlapping in places the older series. They consist as a w of a conformable series of alternating fawn and bluish sandstones shales in the oldest rocks exposed, passing upwards through fa false-bedded, fossil-wood sandstones containing harder lent into soft fawn and whitish sandstones and quartzose gravelly sa with intercalated fresh-water clays, the whole series, with the ception of the lowest rocks exposed, containing abundant f wood trunks. The highest beds are followed by sands which pass soil-cap. Sandy alluvium flanks the Irrawaddy, Chindwin Mu Rivers.

The oldest rocks of the series are only exposed in the soutl part of the range of hills which occur through Sheet $84\frac{N}{8}$, an these intercalated grits broken marine fossils and fish teeth v found; selenite is also present in the shales in small quantitie

In the Myinmu (21° 55′; 96° 35′) vicinity, a conglomerate locally ferruginous and containing quartz, schist, and gneiss pebbles, large ferruginous and silicified pieces of fossil wood and broken mammalian limb-bones, is found lying unconformably on unfossiliferous fawn-coloured sands containing shale intercalations, thin ferruginous bands and hard sandstone lenses. The conglomerate is probably related to the deposits found on the west bank of the Irrawaddy opposite Mandalay and tentatively correlated by Dr. Cotter [1] from their fossil contents with the Pleistocene gravels of the Singu-Yenangyaung area.

It is only in the hills south-east of Ondaw, and east of the Mu and Chindwin Rivers and at isolated localities such as Ywathitgyi and Myinmu on the Irrawaddy, that coherent rocks are seen; elsewhere the soil-cap conceals the solid geology. In sheet 84 $\frac{N}{8}$ volcanic rocks are found at Kyaukka Hill (22° 7′; 95° 17′) and in the small isolated hill, one mile N.E.-by-E. of Thamangon (22° 13′; 95° 18′). In both areas the rocks are characterised by olivine phenocrysts and appear to be basaltic in composition and texture.

Pakokku and Lower Chindwin districts: Burma.

During the season 1925-26 Mr. C. T. Barber was deputed to survey geologically Sheets 84 $\frac{O}{1}$, $\frac{O}{2}$, $\frac{N}{3}$, $\frac{N}{4}$ and parts of 84 $\frac{J}{15}$ and $\frac{J}{16}$ in the Pakokku and Lower Chindwin districts. In February he was transferred to the Myingyan district to continue the geological survey of Mount Popa.

The greater part of the area, apart from an extensive alluvial belt flanking the Chindwin River on the west, is occupied by Upper Tertiary rocks which are for the most part monotonous and uninteresting. In Sheet 84 $\frac{O}{2}$ they are clearly divisible into two series, the Pegus and the Irrawadian, the former characterised by a predominance of blue or grey laminated clays with a subordination of soft, false-bedded sandstones, and the latter by preponderating incoherent sands and gravels with rare intercalated clays. The boundary between these two series follows a north-north-westerly course to the immediate west of the Shinmataung volcanic zone and is one of marked unconformity. It is also characterised by the presence of very ferruginous deposits and the local development of a definite "Red Bed," but this dies out in a northerly direction and the boundary between the two series becomes increasingly difficult to trace, till north of the alluvial tract of the Lingadaw

[1] *Journ. A. S. B.*, N. S., Vol. XIV., p. 418.

Chaung, in Sheet $84 \frac{O}{1}$, they appear to merge into one another by imperceptible gradations and without appreciable unconformity. Here also there is an extensive development of Plateau Red Earth[1] which still further obscures the relationships of the underlying deposits; on lithological grounds a tentative boundary has been drawn passing in a north-north-westerly direction through the villages of Tawma (95° 2′; 21° 48′) and Thanbodaung (95° 1′ 30″; 21° 50′), the rocks on the east, of a predominant clayey facies, being classified as Pegu series, and the sands and gravels to the west as Irrawadian.

The chief interest in this area centres round the occurrence of a varied suite of intrusive and extrusive rocks of late Tertiary age and particularly the presence of contemporaneous volcanic rocks in the Pegu series.

The volcanic rocks of the Shinmataung area (Sheet $84 \frac{O}{2}$) consist of hornblende-andesites, basalts, ashes, and rhyolitic agglomerates and breccias. The relationships of these rocks to one another and to the surrounding Upper Tertiaries are considerably obscured by surface deposits of Alluvium, Plateau Red Earth[1] and Plateau Gravel,[1] but it is worthy of note that these rocks occupy a belt along the Pegu-Irrawadian boundary and that the presence of ashes and rhyolitic agglomerates interbedded in the Pegu series has been clearly demonstrated.

The intrusive and extrusive rocks of the Salingyi uplands (Sheet $84 \frac{O}{1}$) consist of dacites, dolerites, epidiorites and coarse-grained diorites, forming a suite of a dominant calc-alkali type. These rocks have undergone pronounced dynamo-metamorphism accompanied by far-reaching mineralogical changes, the chief of which are saussuritisation of the felspars and uralitisation and epidotisation of the ferro-magnesian minerals. The latter changes have resulted in the formation of two very interesting and characteristic rocks; uralitisation in the production of a felted mass of augite and hornblende, aggregated in such a manner as to suggest ophitic intergrowth, and epidotisation in the production of a pale green compact rock consisting almost entirely of quartz and epidote.

Other features of considerable interest in the Salingyi complex are the intrusion of a more acid granitic rock into typical dolerites

[1] E. H. Pascoe, "The Oil Fields of Burma," *Mem. Geol. Surv. Ind.*, Vol. XL, pt. 1, pp. 29, 30 and 31.

in the neighbourhood of Saga (95° 8′; 21° 57′) and the intrusion of a pegmatite dyke into coarse diorites one-and-a-half miles south-east of Kyaunggon (95° 6′; 21° 58′).

The relationship of these intrusive and extrusive rocks to the surrounding Pegus is obscured by a considerable development of Plateau Gravel, which is impartially distributed over the lower flanks of the igneous rocks and the adjacent Pegus. Nowhere can Pegu sediments be seen to overlie the igneous rocks, but at their south-eastern margin, north-west of the village of Kuntha (95° 8′; 21° 54′), apophyses penetrate the underlying Pegu clays and have apparently been altered in composition by fusion and absorption of the country rock. In spite of the absence of definite evidence in the form of overlying sediments, the general configuration and petrological characters of the igneous mass are such as to leave little doubt that it was formed as a laccolitic intrusion into the Pegus, the sedimentary cover having been removed by denudation.

The igneous rocks of the Ingyin Taung and Powin Taung area (Sheet 84 $\frac{J}{16}$) consist of andesites, rhyolitic agglomerates and fine-grained ashes and tuffs interbedded in the Pegu series, and intrusions of coarse diorites and mica-porphyries. The andesites have locally undergone pronounced silicification yielding an amygdaloidal rock the vesicles of which are filled with chalcedony in beautiful radiating fibres, while the ashes and tuffs have undergone pronounced metamorphism. The latter changes, probably connected with the intrusion of the adjacent diorites, have resulted in the development of sericite and of slaty cleavage, the rock having a remarkably schistose appearance.

Powintaung is flanked on the west by a steep scarp falling away precipitously from its summit some 400 feet. This scarp is continued southwards through hill "815," and northwards through hills "627," "550" and Ingyin Taung, forming a conspicuous feature in the topography. The basal bed of the sedimentary Pegu rocks is here a very distinctive conglomerate, some four feet thick and consisting of rectangular and sub-rectangular fragments of shale in a matrix of soft buff sandstone. It is immediately overlain by a massive sandstone forming the Ingyin Taung scarp and dying out in a northerly direction, till east and southeast of Maukthayet (94° 58′; 22° 7′) it is replaced by alternating shales and sandstones with occasional lenticles of limestone which has yielded a rich fauna of corals, bryozoa, echinoderms and lamellibranchs.

Numerous specimens of these were collected by Dr. Coggin Brown and Mr. Barber and have subsequently been identified by Mr. B. B. Gupta as follows :—

Gastropods . . .	Casts of *Turritella* and *Cypræa*.
Lamellibranchs . .	*Modiola affinis*, K. Mart.
	Modiola sp.
	Pecten sp. allied to P. *zitteli* Fuchs.
	Pecten sp.
	Ostræa sp.
	Lima protosquamosa, Nœtl.
Echinoids . . .	*Brissus* sp. allied to *B. declivis*, H.
	Cidarid spines.
Corals	*Stylophora digitata*, Pallas.
	Calamophyllia sp.
	Leptoria sp.
	Hydnophora sp.
	? *Favia* sp.
	Orbicella defrancei, E. & H.
	Stylocoenia tuberculata, Greg.
	Prionastræa lyonsi, Greg.
	Prionastræa sp.
	Latimeandra sp.
	Pachyseris sp.
	Porites sp.
	Goniopora sp.
Alcyonaria . . .	*Isis compressa*, Dunc.
	Isis sp. 1, Dunc.
	Isis sp. *cf*. sp. 2, Dunc.
	Isis nov. spp.
Crustacea . . .	*Balanus* sp.
	Neptunus sp.
Bryozoa . . .	*Cellepora*
	Retepora ?

These species have been recorded previously from the following localities but, with one or two exceptions, not from the Miocene of Burma :

Modiola affinis, K. Mart.	Miocene, Java.
† Pecten zitteli, Fuchs	Miocene, Egypt.
Lima protosquamosa Nœtl.	Miocene, Burma.
† Brissus declivis, Herklots	Miocene, Java.
Stylophora digitata, Pallas	Miocene, Java.
Orbicella defrancei, E. & H.	Miocene, (cosmopolitan).
Stylocœnia tuberculata, Greg.	Miocene, Egypt.
Prionastræa lyonsi, Greg.	Miocene, Egypt.
Isis compressa, Dunc.	Miocene, India.
Isis sp. 1, Dunc.	Miocene, India.
† Isis sp. 2, Dunc.	Miocene, India.

(Only allied forms of the species marked thus "†" have been identified in the Maukthayet collection.)

In addition to the forms cited above the Maukthayet collection appears to contain several new species.

The Letpandaung and associated volcanics (Sheet 84 $\frac{N}{4}$), consist of rhyolitic breccias and agglomerates, remarkably similar in the hand specimen to the agglomerates and breccias of the Shinmataung area. These rocks form the conspicuous Letpandaung hills rising to a height of one thousand and fifty-five feet on the right bank of the Chindwin River opposite Monywa. From the outside these hills have the appearance of a fluted cone in which denudation has reached a mature stage. From the inside they have a marked crateriform appearance which is also somewhat modified by denudation. The volcanic rocks of these hills are considerably weathered and, as far as can be observed in the field, have also suffered hydrothermal or metasomatic alteration, locally accompanied by the introduction of copper ores changed later into malachite and chalcanthite; it is hoped that the mechanism of the introduction of these deposits will be still further illuminated by the microscopical study of the rocks.

Hill "560," situated just north of the 3rd mile on the Ywashe-Yinmabin road, is also composed of volcanic agglomerates and tuffs which have undergone secondary silicification, while the Kyaungmyet Hills, some four miles to the north-east, are composed of very compact rhyolites and quartz-porphyries with interbedded quartzites.

With the exception of Hill "560" the above mentioned volcanic rocks are entirely surrounded by alluvium so that their relationships to the Tertiary sedimentary rocks of this area are obscure. At the eastern foot of Hill "560," however, metamorphosed Pegu shales and sandstones are exposed, fixing an age limit to the volcanics in one direction. Owing, however, to the mature stage of denudation reached in these hills there is little reason to suggest that the volcanics are of Recent or sub-Recent origin.

Amherst district: Burma.

Mr. P. Leicester, working in the Amherst district, completed Sheets 94 $\frac{H}{12}$, $\frac{H}{16}$, 95 $\frac{E}{9}$ and part of 94 $\frac{H}{11}$. In the course of the survey the following rock types were recognised:—

Alluvium,
Laterite,
Moulmein Limestone,

Sandstone, Quartzite and Shale series,
Granite and Gneiss.

The Taungnyo range, which is the continuation of the Thaton ridge to the south of the Salween, stretches southwards from Moulmein and consists of an unfossiliferous series of sandstones, quartzites and shales with a N.N.W.—S.S.E.'ly strike and an easterly dip of about 45° in the north, changing where the ridge widens farther south to 25°. Laterite occurs on either side of the range. To the west is a band of alluvium broken only by the Amherst hills and the laterite surrounding them, while to the east of the Taungnyo range is a monotonous forest-covered plain revealing nothing but lateritic clay and rubble with a bed-rock of laterite. Patches of alluvium deposited by the river Ataran, the Winyaw river and their tributaries, occur on the plain and to the east of Sheet 94 $\frac{H}{16}$ rise the precipitous hills of crystalline Moulmein Limestone.

The relative ages of the Moulmein Limestone and the sandstones of the Taungnyo range could not be determined as no junctions were to be found in the district, but the solution of this problem may possibly be found in the area farther south where Mr. Leicester will be working during the season 1926-27.

The Amherst hills are lithologically the same as the Taungnyo range. The sandstones and shales are, however, considerably veined with quartz in places and may be traced through metamorphosed sandstones and schists to the injection gneisses, granulites and phyllites of the coast near Amherst, which have been subjected to *lit-par-lit* intrusion of granite, showing that the granite is younger than the sandstone series. The general dip in the hills appears to be to the west, in contrast to the easterly dip of the main ridge ; the strike is the same namely N.N.W.—S.S.E.

Central Provinces Party.

The Central Provinces Party comprised Dr. L. L. Fermor (in charge), Messrs. H. Crookshank and W. D. West, and Sub-Assistant D. S. Bhattacharji. Dr. Fermor paid visits of inspection to each of the members of the party and then utilised the time available, before proceeding on leave in February, in revision work in the Sausar *tahsil*. Mr. Crookshank spent the early portion of the season in completing the mapping of the western part of the Sausar *tahsil*, and then resumed his work taken up in northern Chhindwara in the previous season. Mr. West continued his work on the Deolapar sheet in the Nagpur

district, but his work there was terminated early in order to enable him to visit Kathiawar and then resume his work in the Himalaya. Sub-Assistant Bhattacharji spent the major portion of the season on revision work in the Nagpur district.

Chhindwara district.

Dr. Fermor revised and amplified previous work on the Linga Sheet (55 $\frac{K}{18}$), in the light of the results of work on the Sausar sheet to the south. The southern edge of the Linga sheet is occupied largely by porphyritic, augen, and streaky biotite-gneisses, with bands of coarse hornblendic gneisses, the whole intruded by the fine-grained granite of Amla, often also gneissose. In addition, there is an abundance of marbles and diopsidites of the dolomitic suite (Bichua stage), and a certain amount of older finegrained schistose biotite-gneisses and biotitic schists, and of hornblende-schists; the last are often rich in green augite, when they are comparable with the tarurite of Mysore, in which the augite is supposed to be secondary with reference to the hornblende. The most interesting new fact noticed in the rocks of the dolomitic suite was the passage of scapolite into zoisite, in marbles south of Nauthal.

The various types of ortho-gneisses occur in bands, or tend to do so, and although abundant evidence is seen of the intrusion of the youngest gneisses (the Amla granite and gneiss) into the streaky-lenticle-augen group of gneisses, and of the latter into the subordinate fine-grained gneisses with associated hornblende-schists, yet, on the whole, each belt of rock is described as sheeted and participating in the anticlinal and synclinal folding. Consequently, the form of these ortho-gneiss intrusives is, regarded broadly, sill-like or laccolitic, rather than batholithic.

These gneisses all show marked pitch phenomena and it is of interest to record that the general pitch of the region examined is in direction parallel to the strike of the great reef of fault breccia and belt of mylonitised gneisses lying just to the north of Chhindboh, that is, W.S.W. (see *Records, Geol. Surv. Ind.*, vol. XLIII, pp. 33-34; the zone from Mohkher to Dhanora). A relationship between the two phenomena is thus indicated.

The Kachhi-Dhana manganese mine was revisited and the structure found to be much more complicated than previously suspected, the fold axes possessing this same W.S.W.'ly pitch (actually about W. 15°S.), which is directing the quarrying and mining operations. Associated with the manganese ore deposit is a great variety of fine-

grained granulitic rocks, containing various manganiferous minerals. Amongst the minerals collected is a rose-pink amphibole, perhaps the hexagonite of Dana.

During the first two months of the field-season, Mr. Crookshank completed the mapping of the western part or Pandhurna tract of the Sausar *tahsil*, Chhindwara district. This included parts of Sheets 55, $\frac{K}{6}$, $\frac{K}{10}$ and $\frac{K}{11}$.

Chhindwara district.

Except for a small inlier of crystallines near Goridhana, rocks of the Deccan Trap series occupy the entire area mapped. They include flows, dykes, and Intertrappean beds. Fifteen flows were counted, the average thickness being 75 feet, with a maximum and minimum of 120 and 40 feet respectively. As well as the usual minerals seen in the Deccan Trap flows, zeolites were found locally in great abundance; these include heulandite, stilbite, chabazite, ptilolite and mesolite. The best locality for these minerals is in the hills south of Chicholi. Here they occur as large masses filling the joint planes in the basalt. Several tons could be gathered loose on the surface, and a regular supply could probably be obtained by quarrying in the soft trap, should any market for such material arise.

The dykes were mostly less than 10 feet in width, but one large dyke was noted in the Wardha valley near Marur. This dyke is about 70 yards wide, fills a fault plane, and is regarded by Mr. Crookshank as probably composite, the evidence for this view being, however, not quite conclusive. Under the microscope the dyke rocks differ little from the flows, but they appear to contain a somewhat larger proportion of olivine and apatite. Mr. Crookshank suggests that the minor dykes are only infillings of fissures in the trap and have never been the channels through which the overlying flows have passed. All the dykes have a general east to west trend, though they may vary as much as 30 degrees to either side of this centre line.

Intertrappean beds were not common in the area surveyed this year. The most remarkable instances were a bed of fossiliferous chert near Semardhana (21° 42½′ : 78° 40′) a manganiferous sandstone 1½ miles E.N.E. of Chicholi, and a fairly wide spread of limestone in the neighbourhood of Chicholi.

Minor faults were noted north of Chicholi and in several places along the Wardha river. In one place the evidence of faulting was so good that it was possible to take convincing photographs. On

account of the similarity of the rocks on either side of a fault this is unusual in the Deccan Trap, where faults are generally a matter of deduction

At Goridhana, in the northern part of the area mapped, Mr. Crookshank discovered an inlier of brecciated quartz-rock containing in places porphyritic felspar crystals. This inlier strikes E. 35° N. towards the point where the W.S.W. end of the Chhindboh reef of fault breccia (see page 92), as traced through the crystallines, disappears below the Deccan Trap near Ment, and of which the Goridhana exposure is obviously a continuation. Since Goridhana is also roughly on the line of strike of the Ellichpur fault in the Amraoti district to the S.W., Mr. Crookshank is tempted to regard the Goridhana exposure as evidence of the continuation of the Ellichpur fault into the Chhindboh fault. The Ellichpur fault, however, which lies at the southern foot of the Gawilgarh hills, is a post-Deccan Trap fault with a large downthrow to the south, whilst the Chhindboh fault is a pre-Trap fault along which further movement has taken place in post-Trap times producing a downthrow of the overlying traps, as measured by Dr. Fox, of 150 feet to the north near Ment.

On the Sausar sheet to the east of the tract mapped by Mr. Crookshank, where faults are easier to detect on account of the appearance of the crystallines from below the Trap, Dr. Fermor has mapped a large number of post-Trap faults, and taking into account also the post-Trap faults detected by Mr. Crookshank in the Pandhurna tract, the balance of evidence seems to favour the view that the great post-Trap movement that caused the Ellichpur fault is represented to the E.N.E. in the Sausar *tahsil* of the Chhindwara district by a multitude of faults of smaller throw breaking up the Sausar tract into faulted blocks. It is uncertain whether the Ellichpur fault, if traceable through the traps, would be found to run into the Chhindboh fault or on a parallel course to the S. E. thereof. But the paralellism of these two faults is interesting, and indicates that post-Trap movements in the Satpuras have tended to follow the pre-Trap trend lines. In the case of the Chhindboh fault, an ancient, possibly Archæan, fracture appears to have been reopened in post-Trap times. The term post-Trap is used here as meaning later than the local flows: for in northern Chhindwara (see below) fault movements appear to have begun before the close of the Deccan Trap period of vulcanicity.

On completing his work in the Sausar *tahsil*, Mr. Crookshank resumed the survey of Northern Chhindwara begun in the previous field-season. The area mapped occupies parts of Sheets 55 $\frac{N}{1}$, $\frac{N}{2}$ and $\frac{N}{6}$, and 55 $\frac{J}{15}$, and stretches in a general E.N.E. direction parallel to the Deccan Trap-Gondwana boundary. Generally speaking, the high ground to the south and east is occupied by Deccan Trap, and the low ground to the north and west by Upper Gondwanas. The only other formations seen were recent soil caps at one end of the scale, and a small area of crystalline rocks just encroaching on the northern border of the district, 1½ miles N.N.W. of Harsur, at the other end.

The Deccan Trap series includes in this area flows, Intertrappean beds, dykes and sills. The flows occupy a wide spread of country stretching west and north of Harai as far as the Deccan Trap-Gondwana boundary.

These flows are similar to those of the Sausar *tahsil* but somewhat more varied. They have been extensively disturbed by faulting, as can be easily proved by following their junction with the underlying sandstones; they have also been somewhat displaced by large sill-like intrusions. The number of the flows was not counted, but must be large. The seven lowest, which were specially observed, vary from 40 to 85 feet in thickness and average 56 feet.

On the surface of the Gondwana sandstone immediately below the basalt, Mr. Crookshank has noticed at a number of places parallel striations or scratches, especially along the boundary from the Hard river as far east as Kundali. The cause of these striations is a matter of conjecture, but Mr. Crookshank considers that the most probable explanation is that they were caused in some way by the passage of the molten basalt. If this deduction be correct, then the direction of flow of the basalt must have been along a N.N.W.-S.S.E. line.

Intertrappean beds are for the most part scarce, thin and non-fossiliferous. A cherty layer was, however, found near Sidhauli, which contained abundant remains of *Bullinus* and *Limnæa*. The existence of this Intertrappean occurrence is taken as an indication that the flows on the highest parts of the Satpura in North Chhindwara are homotaxial with those in the plains about Sausar.

Zeolites are widespread, but never very abundant; the commonest are laumontite and heulandite, but stilbite and chabazite were also noted.

The intrusive forms of the Deccan Trap are mostly found north of the scarp marking the junction of the Gondwana and Deccan Trap rocks. To a lesser extent they extend southward into the main body of the basalts. The intrusions are of two kinds—dykes and sills. The former are generally seen east of the Hard river. Here they form a series of elongated lenticles over a hundred yards wide and several miles long. These lenticles most commonly occur in fault planes, and strike in an E.N.E. direction. The rocks of which they are formed vary from fine-grained basalts with tachylitic selvages to coarse and often porphyritic dolerites. Some of the dykes are composite, in which case the basaltic portions are more recent than the doleritic. It is thought that these dykes represent the channels through which the surrounding basalts were erupted.

The sills are irregular intrusions injected for the most part into the Upper Gondwana rocks. Wherever the thickness of the sills is fairly uniform, it exceeds that of the flows and averages about 100 feet. At the junction between the sills and the sandstone there are no striations such as are seen at the base of the flows, not are there any other marked contact effects. At their junction with the basalts, however, the sills have normally been chilled for about a yard inwards from the basalt. Unlike the dykes, the sills vary little in their macroscopic characters; they are all coarse-grained somewhat porphyritic dolerites. Although the sills have their greatest development in the Gondwana area, they are by no means confined to it. In two cases sills were found in the basalts far from the nearest sandstones, and in three others they extend upwards from the Gondwanas into the overlying flows. Mr. Crookshank is uncertain of the distance to which these sills have been intruded into the flows, but it is his impression that they die out after two or three miles.

This great assemblage of dykes and sills in northern Chhindwara is one of the most remarkable features of this interesting district. They were originally noticed by V. Ball many years ago, but, on account of the relatively inaccessible character of the country in which they occur, they have not hitherto been studied with any care.

South of the main escarpment, Gondwana rocks occur only in one or two isolated places, where they form faulted inliers in the Trap. North, east and west, they extend beyond the limits of the area visited during the field-season. They consist of thick beds of sandstone, conglomerate, white and variegated clays, and carbonaceous

and ironstone shales. Mr. Crookshank is at present uncertain to what stages of the Upper Gondwanas these rocks should be referred, and consequently groups them comprehensively with the Mahadeva series. Among the carbonaceous shales fossil plants are fairly common; these are believed by Prof. Sahni to belong to either the Kota or the Jabalpur stage.

Normal and trough faults are common throughout the area surveyed. They are of moderate throw, and strike for the most part approximately E.N.E.-W.S.W. As many of the dykes occupy fault planes, it is evident that the faulting that has so disturbed this region commenced before the termination of the Deccan Trap period of vulcanicity.

Nagpur district.

Mr. W. D. West was able to devote some 10 weeks only to the continuation of work in the Nagpur district commenced in the previous field season. Work was continued on the Deolapur sheet ($55\frac{O}{6}$), and the same formations as last year, namely, Archæan and alluvium, were encountered. The south-western corner of the map has now been completed, and, generally speaking, the results obtained amplify and confirm those of the previous season. An area of some interest is centred round Pindkapar, where the succession exposed ranges from the calcitic marbles up to Ramtek quartzites with some omissions. The rocks are displayed in the form of a flat normal syncline with a southerly pitch, so that the whole outcrop is crescent-shaped, and, as the fold is not an isoclinal one but an ordinary open fold, Mr. West considers that we have here a definite proof of the order of superposition of the rocks of the Sausar series, (*viz.*, that given on pages 78 and 81 of the previous review).

In the previous review reasons were given for supposing that certain gneisses and schists, previously regarded as ortho-gneisses and schists, are really metamorphosed sediments. One of the results of this year's mapping has been to bring out more clearly the field relations of some of these gneisses. In particular it has become apparent that a certain variety of muscovite-biotite-gneiss, which commonly contains small tabloids rich in sillimanite, always occurs at the base of the dolomitic suite, and nowhere else. This criterion of distribution was one of the reasons given last year for thinking that many of the gneisses are of sedimentary origin. To test this, a further analysis was made of this particular gneiss in the hope that the chemical criteria might be of value. In general, argillaceous

sedimentary rocks differ chemically from igneous rocks in showing an excess of magnesia over lime and of potash over soda, and a richness in alumina, as compared with the alkalies and lime. The first two criteria, though not of much use alone, are of considerable diagnostic value in combination. The analysis of this gneiss shows that all these criteria for a sediment are realised, and provides strong additional evidence for thinking this particular rock to be a para-gneiss. Mr. West assumes, of course, that there has not been much change in the bulk composition of the rock during metamorphism.

In two localities Mr. West found outcrops of anthophyllite-schists, associated with rocks of the dolomitic suite.

Nagpur district.

Sub-Assistant D. Bhattacharji spent the major portion of the field season in revising his mapping in the northern portion of the Parseoni sheet ($55\frac{O}{8}$), in the Ramtek *tahsil* of the Nagpur district. This revision was necessary in the light of further experience and information gained in the survey of adjoining sheets, and on account of its extreme complexity of the ground. Mr. Bhattacharji has been able to classify his rocks according to the stages of the Sausar series as given in the tabular scheme on page 78 of last year's General Report. The results of his work go to confirm those of Mr. West, in showing that the tabloid gneisses and sillimanitic gneisses occupy definite stratigraphical positions, confirming the view that they should be treated as para-gneisses and schists. Mr. Bhattacharji gives an account of the general aspect of the rocks of each of the stages of the Sausar series found in the tract mapped, and now that the sequence of these stages has been determined, he is able to unravel the details of the very complex structures of this part of the district.

Towards the end of the season Mr. Bhattacharji commenced work on the Maunda sheet ($55\ \frac{O}{8}$) surveying the N.W. corner. This tract proved to be occupied largely by thick alluvium with inliers of crystalline rocks—pegmatite, gneiss, and amphibolite—in and near stream-beds.

Coal-fields Party.

The re-survey of the Raniganj coal-field was begun in November 1925 under the supervision of Dr. C. S. Fox. He was assisted by Messrs. Sethu Rama Rao, E. R. Gee and A. K. Banerji. These officers worked on the new 4 inches-to-the-mile sheets, which had been specially prepared by the Survey of India, as follows. Mr. Sethu Rama Rao mapped the extreme western end of the Raniganj coal-field (sheets 1, 2, 3, and

part of 5). Mr. E. R. Gee re-surveyed the north-central portion of the field (sheets 7, 8, and 11). Mr. A. K. Banerji devoted the whole of his time to the difficult task of tracing the seams in the area which lies immediately on each side of the Barakar river (sheets 4 and 5). Dr. Fox worked with each member of his party for a time, and also made a rapid examination of the whole field from the vicinity of Durgapur, east of Ondal, in the Burdwan district to beyond Nirsha-chatti in the Manbhum district, and from Saltore on the Damuda to the trans-Adjai area of Kasta.

In addition to his duties in the Raniganj coal-field Dr. Fox paid frequent visits to the Jharia coal-field in order to prepare for the re-survey of this important area in the next field season. Visits to the Giridih coal-field were also made for an investigation of the origin of the phosphorus in Indian coals. Early in 1926 an inspection of the geological features in the Talchir, Rampur (Ib river), Korba, Sohagpur and Umaria coal-fields was made by Dr. Fox. While at Umaria he noted the unconformity between the Talchir Boulder beds of Umaria and the *Productus* horizon overlying it in the Narsara cutting near Umaria. Later in the season Mr. Gee re-mapped the area to the west of Umaria and made a more complete collection of fossils than had been previously possible.

During his rapid examination of the Raniganj field Dr. Fox was able to visit the Tata Iron and Steel Co.'s smelters and furnaces at Jamshedpur, the works of the Bengal Iron Co. Ltd. at Kulti, the plant of the Indian Iron and Steel Co., at Hirapur, the Kumardhubi Engineering and Fire-brick works, the Raniganj Pottery and Tile works, and various other manufacturing centres employing coal fire-clays. One of his more important duties was the collection of data relating to the coking properties of the coals in the Raniganj coal-field, and the outturn of soft coke for domestic consumption in Calcutta and other large towns in Bengal, Bihar and the United Provinces. In view of a common but erroneous assumption that none of the Raniganj coal possesses coking properties of first class importance, it is interesting to learn that, among the better class Raniganj coals the following are known to be of coking quality :—

(*i*) Dishargarh. This has been used alone for blast furnace work but gives better results when mixed with some Jharia seams ; it also gives an excellent coke when mixed with Karanpura (Sirka-Argada) coal in equal amounts.

(*ii*) Sanctoria-Poniati. This is known to be of coking quality but no tests have been made with it either along or mixed with other coals.

(*iii*) The Chanch-Begonia seam. This gives a firm coke, and might be suitable for blast-furnace purposes if mixed with another coal such as Dishargarh.

(*iv*) Ramnagar. This coal has been used alone for blast-furnace coke at Kulti for many years. It however, gives a better product when mixed with Jharia coal from Jitpur.

(*v*) Laikdih. It is assumed that the seams in Victoria colliery represent the Laikdih (thick) seam of the Kumardhubi area. This coal cokes very well and is thought to be utilizable for metallurgical purposes. It would probably give better results if blended with other coals.

In addition to the above coals there are large quantities of poorer quality coal, *e.g.* in the Borachuk seam and some seams near Mugma, which cake strongly and furnish nearly all the soft coke from the Raniganj field. Dr. Fox is conducting a series of large scale experiments with the above mentioned good quality coals of the Raniganj field with a view to indicating local supplies of metallurgical coke in the vicinity of the smelters at Kulti and Hirapur. Seeing that the Chanch-Begonia, Ramnagar, and Laikdih seams belong to the Barakar stage, and are therefore the equivalents of the Jharia seams, it is not unreasonable to expect these seams to give as good coking results, either when used along or blended with Dishargarh coal, as the Jharia coals.

With regard to the subject of soft coke a great deal of work has still to be done. The production of soft coke in 1925 was no less than 408,969 tons of which the Raniganj field supplied 113,173 tons from the Mugma area and 7,471 from the Kalipahari vicinity, as against 290,807 tons from the Jharia field. Small but steadily increasing amounts of soft coke are being made in the Bokaro field in Bihar and in the Lakhimpur area of Assam. This evidence of an increased use of coke in place of wood and charcoal is important, as greater demand may allow of the large reserves of these inferior coals being partially carbonized and retailed in village areas on a vast scale. Such a trade would do much to save the burning of cow-dung, the present fuel of large numbers of people and a valuable fertilizer. The exploitation of India's enormous supplies of second class coal, especially

of that capable of yielding a soft coke, should play a prominent part in the improvement of the agriculture of the country. In his work on the presence of phosphorus in the Giridih coals Dr. Fox was able to prove the existence of a low-phosphorus coal in attractive quantities in the Kharharbari colliery workings. His results have been made public in another part of these Records.

The work of re-surveying the Raniganj field—25 sheets on the scale of 4 inches to the mile—will, it is estimated, be completed in 1927. It is hoped that the Jharia maps on the same scale will soon be available so that the re-survey of this area can be commenced.

Madras.

Work was resumed in the North Arcot district of Madras on Survey sheet 57 $\frac{P}{1}$ in the neighbourhood of Katpadi by Mr. Vinayak Rao, but, owing to the number of economic enquiries, very little time was left for systematic survey work. The rocks south of the Palar are charnockites, whereas to the north acid granites with pegmatite veins and dykes running in an east-and-west direction are found; one band at least appears to be later in age than the charnockites.

North-Western Party.

The North-Western Party consisted of Dr. G. de P. Cotter, in charge, Messrs. D. N. Wadia and J. A. Dunn, Assistant Superintendents, and Sub-Assistant H. M. Lahiri. Mr. Dunn was transferred to the Bihar and Orissa party in December 1925.

Dr. Cotter, accompanied by Mr. Lahiri was employed in the survey of the Kala Chitta Hills and adjoining country in the Attock district. Dr. Cotter was mainly engaged in the survey of sheets 43 $\frac{C}{6}$ and $\frac{C}{10}$, parts of which had been already surveyed and described in my own Memoir[1]. Dr. Cotter's work covers the intervening ground between my two maps and also joins his geological map with that of Mr. Wadia to the east (sheet 43 C-14), made in a preceding season.

The formations met with were Murree beds, the Chharat series, Lower Nummulitics, Giumal beds, and Trias. The lithology is described as exactly similar to my description in my notes on the Chak Dalla area (*vide supra*). The structure is isoclinal, but in a few sections there are traces of anticlinal crests. The softer beds between the Lower Nummulitic and Triassic limestone are attenuated and sometimes

[1] Pascoe; *Mem. Geol. Surv. Ind.*, vol. XL, part 3 and plates 71 and 73—Geological maps of the Fatehjang and Chak Dalla areas.

entirely removed by *chevauchement*. The following Assiline species, in addition to those mentioned by myself, occur in the Nummulite Shale, which forms the uppermost bed of the Chharats :—

Assilina spira De Roissy.
Assilina papillata Nuttall.

In marls immediately underlying the Nummulite Shale, abundant lamellibranch casts were found near Gadowala 3 miles north of Fatehjang. None of these were specifically identifiable, but two species may be doubtfully compared to. *Cardita subcomplanata* D'Arch. and *Pholadomya halaensis* D'Arch. In the Lower Nummulitic limestone *Assilina granulosa* and small foraminifera of the *Tetxularia* type were observed.

Kurram Valley.

In February Dr. Cotter paid a brief visit to Parachinar in the Kurram Valley in connection with water questions (see *ante* p. 72), but in the short time at his disposal was only able to make brief notes on the geology.

For the first 19 miles out of Thal on the Thal-Parachinar road, red, chocolate and greenish shales and sandstones of the Subathu series, and limestones of probable Eocene age were seen.[1] Beyond this point nothing but sub-Recent gravels were seen as far as Parachinar, which itself is in the middle of a wide gravel slope bounded by the foothills of the Safed Koh on the north, by the Peiwar Kotal spur to the west and by the Kurram River to the south.

The outermost rocks of the Safed Koh are slate and shale with interbedded limestones, much disturbed and contorted. This group is succeeded to the north by a limestone series,containing remains of crinoids near the top, and with a belt of highly siliceous greenish grey limestone near the base.

The main range of the Safed Koh was not examined, but a collection was made from the boulders in the stream bed at Lukman Khel, a village 5 miles N. W. of Parachinar. These comprise coarsely crystalline granite gneiss, biotite gneiss, biotite schist, white quartzite, ferruginous quartzite with vein quartz, slate, and two kinds of olivine dolerite; in one specimen of the last the olivines are quite fresh, and in the second are altered to secondary hornblende, so as almost to render the rock an epidiorite.

[1] See *Rec. Geol. Sur. Ind.*, XII, p. 100.

The spur running south from the Peiwar Kotal was examined near Kharlachi post about ten miles west of Parachinar. Here were found serpentines intrusive into limestone and peridotite almost completely serpentinised. Veins of very poor quality asbestos were seen. It seems probable that the serpentine represents the upper Cretaceous as elsewhere in India.

The crinoid limestone may be compared to similar limestones in Afghanistan mentioned by Griesbach and by Hayden, (see Hayden: Geology of Afghanistan; *Mem., Geol. Sur. Ind.* XXXIX, p. 15) and is perhaps of Devonian age.

Punjab and Kashmir.

The areas visited by Mr. D. N. Wadia during the season included (1) the Soan area, (2) the Hazara border (Margala hills) and (3) the Pir Panjal (Poonch).

Soan Valley, Punjab.

Geological mapping of the Soan area was continued along the south-western edge of the Potwar plateau. The junction line of the Potwar Siwaliks with the Eocene of the Salt Range along this edge is thought to denote an important unconformity. The basal Siwaliks (Kamlial) rest upon clean dip-slopes of Upper Nummulitic limestone (belonging to the "Nummulite Shale" horizon) without any physical discordance, the lowset beds of the Kamlial containing *Mastodon*, along with derived *Assilina exponens* and *Nummulites atacicus* from the underlying limestone. The unconformity is not an erosional one but is due to the non-deposition of the entire Murree series missing from the sequence. Further east and north-east along the Bakrala flank, the unconformity is described as replaced by a thrust-plane, successive belts of the Potwar Siwaliks being juxtaposed to the Eocene, Cretaceous (?) and Palæozoic rocks constituting the central axis of this offshoot from the Salt Range.

South of the wide and deep trough of the Soan syncline lies the much shallower Chakwal syncline. The sequence of stages, from the upper Oligocene to the Pleistocene, laid bare on the limbs of these two trough-folds, is one of the most complete seen anywhere in the Punjab. A fairly representative fauna of *Equidæ*, *Rhinocerotidæ*, *Suidæ*, and *Tragulidæ* with species of *Hyæna*, *Cervus*, *Giraffa*, a large number of antelopes and the remains of two anthropoids, belonging to the Tatrot, Dhok Pathan and Chinji stages, was collected during this season. The major part of these were obtained by Field-Collector Aiyengar who was deputed to collect from localities which

had been found to be promising during the previous season's work of Mr. Wadia.

About 5 miles north-west of Chakwal, near the village of Joya Mair is a dome-fold in the middle Siwalik sandstones, containing an irregularly elliptical core of Chinji shales. Structurally the Joya Mair fold belongs to the semi-dome type of anticline. The southern half is very like the flank of a steep anticline while the northern part shows qua-qua-versal dips of 10°-30°. The effective storage area enclosed was estimated to be about 5 or 6 square miles, and the prospects of such a fold structure in an area of active petroleum exploration is regarded by Mr. Wadia as not without promise.

Hazara district, Punjab.

The Margala Hills forming the southern border of Hazara show a series of inversions of Cretaceous and Eocene limestone, generally overthrown to the north and thrust over the Murrees. The Darabwali spur from these hills, which is barely 1,200 yards wide, was found to contain four imbricated recumbent folds. About a dozen sulphur springs, including one dry seepage of sulphuretted hydrogen gas, occur along the southern margin of the Margala. The springs in most cases either issue directly from the Upper Nummulitic gypseous shales or are closely associated with them. No oil indications are present in the springs.

Poonch.

Towards the end of the field-season, a short visit paid to the Poonch Pir Panjal enabled Mr. Wadia to map in further detail the obscure belt of rocks which intervenes between the Purana Dogra slates and the Gondwanas of the Gagrian valley. The rocks are greywacke-slates and phyllites containing all but obleterated traces of fossil remains. These are probably a western extension of the Silurian slates of Kashmir and are, like the latter, succeeded by a great development of quartzites and quartz-schists. On the same analogy, therefore, they should correspond to the Muth series (Devonian). No fossils occur in the Muth series of Poonch as they do in that of Kashmir.

The important question of the continuity of the Poonch Gondwana zone with Mr. Middlemiss' *Gangamopteris*-bearing beds of Gulmarg could not be solved as the crest of the Panjal chain, for many miles, was snow-bound beyond the 10,000 feet limit. Such observations, however, as it was possible to make at 11,000 feet altitude, indicate that the inner boundary of the Poonch Gondwanas with the Panjal trap at the Chor Panjal pass is in direct strike continuity with the junction of the Gulmarg plant-beds with the trap, the two places

being barely $3\frac{1}{2}$ miles apart. Unless, therefore, the sequence near Gulmarg is complicated by folds, exposing inlier-masses of older beds, the probability is, as Mr. Wadia points out, that the plant-bearing outcrop forms the extreme bottom-limit of the Gondwana series of Poonch, with which it shares common dip and strike relations.

Attock district : Punjab.

The area surveyed by Sub-Assistant H. M. Lahiri lies mostly in the Fatehjang *tahsil* but partly in the Pindigheb *tahsil* of the Attock district and comprises the whole of Sheets 43 $\frac{C}{11}$ and small isolated portions of 43 $\frac{C}{6}$ and 43 $\frac{C}{10}$. His work in 43 $\frac{C}{6}$ and $\frac{C}{10}$ lay in connecting up the surveys already made by the writer and Dr. G. de P. Cotter.

The geological formations mapped in the Chak Fateh Khan Reserve of the Kala Chitta Hills (Sheets 43 $\frac{C}{6}$ & $\frac{C}{10}$) consisted of the Giumals and Lower Nummulitics. The Giumals occur as narrow elongated inliers in the Nummulitics which constitute the bulk of the hills. They consist of well-bedded ochreous limestone with a characteristic sandy layer with *Belemnites*. This sandy bed at one place yielded a *Perisphinctes* which is considered by Dr. Cotter as close to, if not identical with *P. bleicheri* de Loriol, a species occurring in the Umia beds of Cutch; its occurence forms additional evidence in favour of the Lower Cretaceous age of the Giumal beds. The Nummulitics consist of massive fossiliferous grey limestone called Hill Limestone by Wynne and others. The beds are folded in isoclinal folds with general northerly dips.

The geological formations exposed in the area covered by 43 $\frac{C}{11}$ and the south-eastern quarter of 43 $\frac{C}{10}$ are the following:

4. Alluvium
3. Siwalik series
2. Murree series
1. Nummulitic series

The outcrops of the Nummulitics in the area are confined to the Khairi Murat and the Dhok Maiki ridges. A complete section of the Nummulitics developed in the area is seen along the Chorgalli track about 1 mile south of Pind Fateh (33° 28′; 72° 41′). The lowest bed of this section is the same fossiliferous massive Hill Limestone as that which forms the bulk of the Kala Chitta Hills. The massive limestone is overlain by some well-bedded chalky limestone beds which together with the Hill Limestone undoubtedly correspond to the "Massive Limestone and Passage Beds" stage of the Chharat

section. At Chharat and Chorgalli alike, these lower beds are succeeded by some variegated or green shale with thin partings of marly limestone. This stage, the Lower Chharat, is of much smaller thickness at Chorgalli than at Chharat. The green shale series of Chorgalli is capped by a thin hard greyish limestone which together with the underlying green shale and chalky beds are the only members of the Nummulitic exposed west of Chorgalli. The Upper Chharat is not represented in this area. The fossils in the Lower Nummulitics are small foraminifers belonging to the genera *Nummulites*, *Assilina* and *Dictyoconoides* (=*Conulites*).

The Nummulitics are overlain unconformably by the Murrees which occupy quite a large tract of country in the northern half of the sheet. The lowest bed, as usual, is a conglomerate with derived nummulites and vertebrate remains. The beds of the "Upper Murrees" yielded, near Khidwal (33° 24′; 72° 35′), some *Rhinoceros* teeth which seem close to *Rhinoceros sivalensis* var. *gajensis* Lyd. from the Gaj bed of Sind. Fragmentary vertebrate bones, chiefly reptilian, are occasionally met with in the Lower Murrees also.

South of the Khairi Murat and Dhok Maiki ridges the Upper Murree rocks pass quite conformably into the Siwaliks which occupy a large area in sheet 43 $\frac{C}{11}$. The principal outcrop of Siwalik beds covers the whole of the south-eastern half of the sheet.

The Kamlials or the basal Siwaliks form a characteristic stage distinguishable from the underlying Upper Murrees or the Chinji zone above, by their hard, rather dark, red or purple sandstones. They often constitute strike-ridges which can be traced across the country for miles. These beds abound in vertebrate remains. The Chinji beds have more clay than sandstone towards the base, but higher up the proportion of sandstone increases until the sandstones and clays are equal in amount in the Middle Siwaliks. The Middle Siwalik sandstone is usually massive and soft. A gritty rock with quartzite pebbles and derived nummulites is noted by Mr. Lahiri as occurring near the base of the Middle Siwaliks. Pseudoconglomerates occur throughout the Lower and Middle Siwaliks, true conglomerates also appearing in the Middle stage. The Middle Siwalik beds pass gradually into the true conglomerates and grey sand-rock of the Upper Siwaliks. The boundaries between the various stages of the Siwaliks above the Kamlial stage are indefinite and uncertain. Vertebrate fossils are found in all the four stages of the Siwaliks, but they are less common in the Chinjis than in the others.

Immediately north of the Khairi Murat and Dhok Maiki ridges, the Lower Murrees rocks are exposed in isoclinal folds with the dips either vertical or steep. Further north, *e.g.* near Kot Fateh Khan (33° 28′ ; 72° 31′) and S. E. of Fatehjang (33° 34′ ; 72° 39′) the dips of the beds vary from 50° to vertical and indicate in places an anticlinal or synclinal structure. The isoclinal zone is succeeded southwards by the anticlinal structure of the Khairi Murat and the Dhok Maiki ridges. The fold becomes reduplicated westwards and, south-west of Jhandial (33° 23′ ; 72° 34′), a sigmoidal outcrop of Siwalik rocks makes its appearance in a pitching syncline in the middle of the major anticline. The major anticline is flanked on both sides by Siwalik beds. The Siwaliks occupying the southern flank of the anticlinal fold form the southern fringe and flank of the great Soan syncline.

Rajputana Party.

During the field-season the Rajputana Party consisted of Dr. A. M. Heron, Officiating Superintendent (in charge), Messrs. A. L. Coulson and E. J. Bradshaw and Dr. S. K. Chatterjee, Assistant Superintendents and Sub-Assistant B. C. Gupta.

Mr. Coulson continued his survey of the Sirohi State and the other members of the party worked in the Mewar (Udaipur) State.

Dr. Heron, for the first week worked in the neighbourhood of Chitor and then marched north-eastwards to join Mr. Bradshaw, examining with him the complicated structures of the Jahazpur ridges. Dr. Heron then returned towards the railway, revisiting on the way portions of the Mandalgarh hills and the Upper Vindhyans in the neighbourhood of the Great Boundary Fault. Later he joined Mr. Coulson at Pindwara and spent the ensuing fortnight with him, studying the basement complex, the Erinpura granite and the Malani volcanics in the neighbourhood of Mount Abu, Sirohi town and Pindwara. Dr. Chatterjee arrived at Chitor on the 23rd of December, and after marching across country from Chitor to Udaipur, joined Dr. Heron near there on the latter's return from Siroh. During the remainder of the field-season he accompanied Dr. Heron for instruction, except for about the last month, when he worked independently in continuing the Delhi-Aravalli boundary northwards to join up with Dr. Heron's work in Ajmer-Merwara in 1923-24.

The main objective of Dr. Heron this season was the tracing of the unconformity at the base of the Delhi system, through Central

India and Rajputana Standard sheets (1 inch-to-1-mile), Nos. 142, 143, 144, 145 and 170.

Mewar State.

The central plain of the Mewar State is occupied by a complex assemblage of schists and gneisses belonging to the Aravalli system (Archæan). The fundamental members of the complex appear to be biotite-muscovite schists and chlorite schists. The distinctive character of this system locally is, however, the extensive development of "composite gneisses" and the heterogeneity of types, as contrasted, for instance, with the areas surveyed by Messrs. Bradshaw and Gupta in the north-eastern portion of the Mewar plain (pp. 115-119). In addition to various basic intrusives, now represented by epidiorites and hornblende-schists, there are reasons for believing that there was more than one kind of granite magma. These, with their respective pegmatites, were injected along the planes of foliation of the fundamental rocks, disintegrating them and rendering them plastic, and perhaps even melting and assimilating them. In the northern portion of the Aravalli area biotite-gneisses predominate; these are grey, medium-grained rocks, sometimes with coarse and perfect bending and sometimes with large phenocrysts of felspar. Their foliation is N.E.-S.W. or N.N.E.-S.S.W. They consist of quartz, microcline and plagioclase, green biotite, apatite and purple sphene.

The granites and pegmatites are sodic rather than potassic in composition; plagioclase is more abundant than microcline. Inclusions of zircon commonly occur in the felspars and biotite is a constant constituent. Unlike the post-Delhi pegmatites, these pegmatites are not coarse and contain neither muscovite nor tourmaline.

Just below the base of the Delhi system, epidiorites are in places specially abundant in the ancient complex, but it is uncertain whether they represent effusives, erupted upon the Aravalli surface before the accumulation of the Delhis commenced, or are intrusives of pre-Delhi age congregated just below the old surface, or are post-Delhi intrusives which have ascended along the plane of weakness afforded by the junction of the two systems. The old Aravalli surface is marked by copper-staining; this is not seen everywhere along it, but is fairly frequent. Pebbles of green-stained quartz derived from this are found in the overlying Delhi conglomerates, showing that the copper-bearing solutions were pre-Delhi in age.

As is almost always the case, the junction between the Delhi and Aravalli systems is marked by an abrupt change in topography,

the Aravallis giving rise to a plain, while the Delhi synclines are occupied by high strike-ridges formed by the quartzites, with narrow valleys between.

To the east of Udaipur City, (sheet 145) the conglomeratic quartzite immediately upon the Aravallis is thin—50 feet as a maximum—and it is often entirely missing. Upwards it is succeeded by arkose alternating with biotite and chlorite schists evidently the result of the disintegration of the Aravallis. Next follows a much thicker quartzite, forming a bold but discontinuous ridge, clearly broken in places by dip-faulting, and in other places repeated or eliminated, in the way which is so frequent, and so puzzling in these Delhi quartzites.[1] The general strike is N.N.W.-S.S.E. and the dip 40° to the W.S.W. (*i.e.*, away from the Aravallis) in the south of sheet 145, steepening to verticality and even inversion towards the north.

Above this quartzite is a variable thickness of biotite and chlorite schists, with much amphibolite, and thin lenticular beds of quartzite and very impure limestone.

The next formation is a great accumulation—several thousand feet—of arkose grits with conglomeratic layers giving a width of outcrop of from one to two inches on the map. Their junction with the underlying biotite and chlorite schists is an abrupt one, and they graduate upwards, through passage beds of arkose, into fine-grained reddish quartzites. The pebbles in the conglomeratic bands consist chiefly of quartz and quartzite, with some of granite, and are rolled out in baton-like forms, like the pebbles of the Bar conglomerate in Jodhpur on the other side of the syncline; here, however, the pebbles are smaller on the average, few being longer than one foot in their greatest dimension, that is the direction of the dip, and most of them being six inches or less.

The next succeeding formation is a thick series of thin-bedded, reddish, fine-grained quartzites, with slaty intercalations, forming the high, bold ridge which is pierced by the Debari pass leading from the plain of central Mewar to the "Girwa," the well-watered valley which surrounds the capital. Above these are the softer rocks forming the floor of the "Girwa,"—calcareous sandstones, slates, etc.—which have not yet been examined.

North and south of Dilwara (24° 46′ : 73° 47′) a portion of the boundary had to be temporarily omitted, and where it was picked

[1] General Report, 1925, *Rec., Geol. Surv. Ind.*, LIX, p. 95.

up again, the succession in the Delhis is quite different. Here, in sheet 144, the lowest formation of the Delhis is a grey, almost structureless quartzite, much shattered, and injected with fine joint-veins of white quartz, and with no sign of grit or conglomerate. It varies greatly in thickness, and consequently in prominence, from point to point, and is in places repeated more than once by strike faults and minor folds. Above it is a very variable width of mica schists and amphibolites, and then comes the broad plateau expanse of the Rajnagar marble, a pure white dolomite according to Dr. Chatterjee's analysis.

At Nathdwara (24° 56′ : 73° 52′) these three formations are disposed in a fairly simple syncline, with the Aravalli mixed gneisses on either side, but about 4 miles E. N. E. of Nathdwara the syncline pitches downwards and widens greatly, the central portion being occupied by a broad expanse of black biotite-schists, often highly garnetiferous and everywhere intruded by large quartz veins. Between the marble and these biotite-schists about 20 to 30 feet of flaggy, micaceous quartzite intervenes.

On each side of the expanse of biotite-schists the marble lies in a Y-shaped outcrop, extraordinarily attenuated as compared with its width at Nathdwara. The southern branch dies out about the eastern edge of sheet 144, seemingly disappearing amidst mixed gneisses, with two small disconnected portions along the strike-continuation, as if drifted off into the gneisses.

For a considerable distance out on the gneissic plain S. and S. E. of Nathdwara, interrupted ridges of quartzite, and to a lesser extent of marble, form winding lines of outcrop. In these, every stage is found between undoubted sedimentary quartzites to portions which are almost unmappably vague, grading insensibly into the surrounding granite. Dr. Heron believes that these represent the tips of Delhi synclines, which have been so deeply folded down into the underlying complex that they, and the older gneisses and schists surrounding them, have reached the "zone of flowage," or even a depth sufficient to cause them to be partially remelted. In these conditions, he notes, the biotite-schist portions of the cores have been so thoroughly permeated with, or stoped out by moving magmatic material as to become indistinguishable from the older complex, leaving the quartzites and the limestones, broken up and separated, as disarticulated skeletons of the synclines. In certain cases the cores

are occupied by amphibolite, which may indicate the absorption of the limestone.

In sheet 143 the basement quartzite, with the Rajnagar marble and the schists above and below the latter, form a complicated syncline, which on the map resembles in outline the head of a claw-hammer. Both the quartzite and the marble are effected by imbricate faulting around the margin of the syncline and the quartzite, always very thin, is often missing. The marble is subject to the strangest variations in the width of its outcrop, sometimes being not more than 50 feet wide, and in places half-a-mile. This cannot be attributed, except to an unimportant extent, to differences in the angle of dip, but is, in Dr. Heron's opinion, a real variation due to attenuations in places and swelling in others. At Rajnagar (25° 4′ : 73° 55′) the thickness is of the order of 500 feet.

Where the base of the Delhi syncline bends round the Raj Samand, the great artificial lake at Rajnagar, the lowest bed, equivalent to the quartzite elsewhere, is a boulder conglomerate, 30 feet thick as a maximum, in which the boulders are grey quartzite and red pegmatite. In the centre of the syncline the marble appears in several places through anticlinal buckling of the trough, the largest outcrop of these covering an area of about 8 square miles; this large expanse is due to a series of isoclinal corrugations.

This syncline affords good examples of how various types of gneiss may arise in different ways from the injection of one fundamental rock, in this case a biotite-schist. Starting from biotite-schist, we may have it intruded by large definite dykes of pegmatite, or by clusters of large sills with their feeder dykes, to such an extent that little schist is visible; there are also large areas in which the schist is intimately and uniformly injected by multitudinous interfolier veins of pegmatite, producing as an end-product, a banded composite gneiss, often highly contorted.

To the east, "the claw-end of the hammer," this syncline splits into two and disappears in sheet 170, frayed out and injected by amphibolite and pegmatite, as it reached, in its downfolding, deep-seated regions of plasticity and igneous activity.

From Nathdwara westwards, the boundary of the main Delhi syncline has an E.-W. trend, following more or less the line of the Banas River. Where the Banas issues from the high hills at Katar (24° 53′ : 73° 37′) the boundary swings sharply to a N.E.-S.W. direction and in the angle the beds are intricately folded, not only on a

mappable scale, but in complicated swirls of the bedding, and in crumplings a foot or so across. South of the Banas the basement beds consist of two, or three, thin limestones, separated by a porphyritic rock suggesting "augen-gneiss," the origin of which is uncertain; these are succeeded upwards by felspathic schists, then hornblende and chlorite-schists, topped by conglomeratic and gritty quartzite. Above this is a wide expanse of biotite-schists, and then the Rajnagar marble. North of the Banas practically all of these formations disappear but Dr. Heron's work was here terminated on his recall to Head-quarters. After his departure Dr. Chatterjee continued mapping the boundary north-eastwards to join up with Dr. Heron's work in Ajmer-Merwara of 1923-24; he found the succession in the Delhis to be substantially the same as in Merwara, a strong quartzite at the base, followed upwards by biotite-schists, calc-gneisses and biotitic limestones.

Sirohi State.

Mr. A. L. Coulson spent the season in the Sirohi State of which about 700 square miles were geologically surveyed, on the Central India and Rajputana 1-inch maps, Nos. 94, 95, 96, 117, 118, 119. This work was in continuation of that of the previous season.

The age of the fundamental rocks, which belong either to the Delhi or Aravalli systems, is uncertain and may have to await definite determination until this area has been connected up with Dr. Heron's surveys in Jodhpur and Ajmer-Merwara. Their general strike is N.E.-S.W., with steep dips; lithologically they comprise slates phyllites, mica-schists, limestones and calc-schists, with subordinate quartzites. The limestones and calcic rocks lie principally in the region between the railway line and Mount Abu, and are quarried for lime and for building stone.

The fundamental formation is introduced by basic rocks of apparently two ages; the older comprise epidiorites, hornblende and tremolite-schists and amphibolites, all of which seem to be definitely older than the Erinpura granite. There are, however, as elsewhere in Rajputana, younger dolerites which penetrate the Erinpura granite as well as the basement series.

Where the granite and its accompanying pegmatite have intruded the earlier basic suite, various products, which Mr. Coulson designates "absorption" rocks, have sometimes been formed; these he believes to be the result of assimilation of the basic rocks by the granite and its pegmatite. The more granite-like types are charac-

terised by the presence of quartz, orthoclase, plagioclase, hornblende, garnet and sphene, and grade into the amphibolitic types, in which the chief minerals are hornblende, diopside, biotite, quartz and orthoclase.

The Erinpura granite is by far the most important of the intrusives. It forms the great hill mass of Mount Abu, attaining a height of 5,650 feet in Guru Sikkar, and several square miles of the broad saucer-shaped summit lie at an elevation of 4,000 feet. The width of the granite belt is as much as 12 miles across the strike and it extends to the N.E. and S.W. far beyond the limits of the present survey.

The name "Erinpura granite" is due to LaTouche (*Mem. Geol. Sur. Ind.,* XXXV, pt. 1, pp. 18-19). Characteristically it contains large phenocrysts of microcline, sometimes 3 or 4 inches in length, with quartz, plagioclase, abundant biotite and frequently hornblende. The usual variety is gneissic, strongly foliated, with a parallel arrangement of the minerals; a coarse-grained type has very large felspars and quartz and is unfoliated. The more biotitic varieties weather more readily than the quartzose types and to this is perhaps due the relative eminence of the Abu *massif*. The granite is accompanied by the usual pegmatites, composed of quartz, felspar, muscovite and tourmaline.

The remainder of the rocks are definitely younger than the fundamental series and the Erinpura granite, and are all genetically connected with the Malani rhyolites of LaTouche (*Mem. Geol. Surv. Ind.*, XXXV, pt. 1, pp. 19-24, 78-90) and the Jalor and Siwana granites of that author (*Op. cit.*, pp. 24-25, 90-91). In the extreme north of the State there is a great ridge of rhyolites near Las (25° 7′; 72° 51′) associated with several outcrops of granite around Ban (25° 5′; 72° 55′). The rhyolites are very variable in colour—red, black, brown, green and even white, and under the microscope show blebs of quartz and orthoclase in a glassy groundmass, which, more often than not, is highly devitrified, and in the Ora (25° 2′; 72° 51′) rhyolites, chloritisation has taken place.

The felspars are frequently kaolinised and, as LaTouche describes, mosaics of quartz and corrosion of the quartz crystals are common. Banding and flow structure are commonly seen. Near Mosul (25° 6′; 72° 56′) a small patch of slates, belonging to the basement series, is exposed, with the rhyolites overlying them.

The relation between the rhyolites and the granite is seen north of Ban, where there is a chilling of the edge of the granite resulting in a granite porphyry. Mr. Coulson does not believe that there is much difference in age between the two, but that the granite is slightly younger than the rhyolites. At Andor (25° 2′; 72° 54′) rhyolitic tuffs appear to overlie the granite, and a felspar-porphyry dyke intrudes it.

Mineralogically the Ban granite contains quartz, kaolinized orthoclase, biotite and hornblende and it evidently corresponds with the Jalor granite of LaTouche (*Mem. Geol. Surv. Ind.*, XXXV, pt. 1, pp. 25-5. 90-1). Nodules which project from the surface on weathering contain blue tourmaline, muscovite, quartz, oligoclase, orthoclase and (?) fluorite.

Near Isri (24° 44′; 72° 51′) there is an interesting suite of igneous rocks, comprising tuffs, agglomerates, rhyolites, porphyries of various types, and granite; all are considered to be differentiates of the Isri granite magma, erupted or intruded at successive stages of its cooling. The granite contains abundant felspar, and usually shows perthitic and microperthitic intergrowths of orthoclase with an acid plagioclase. Quartz, of course, is always present, hornblende predominates over biotite, and muscovite is uncommon. The felspars are kaolinised, and epidote and chlorite are common alteration products of the ferro-magnesians. The rock varies greatly in grain, there being every gradation from coarse to very fine. It resembles the Waloria granite met with last season on the Mewar border.

Mr. Coulson remarks that probably at the time of the first intrusion of the granite, the volcanic agglomerate at Sindret (24° 50′; 72° 50′) was formed. This occurs near the junction of the Erinpura granite with the basement rocks, a likely place for fracture to occur. The agglomerate contains large rounded blocks of Erinpura granite and of rocks of the basement series set in a purplish-red ferruginous matrix.

Contemporaneously with this paroxysm the tuffs of Varela (24° 48′ : 72° 49′) appear to have been formed. These tuffs are overlain by a rhyolite, more quartzose than those near Las already described, and tuffaceous and agglomeratic at its base. The rhyolites are practically identical with the hypabyssal quartz-porphyries, which intrude the Sindret agglomerate, and there are all gradations between the quartz-porphyries and the felspar porphyries.

Near Sindret the rhyolites are overlain by more basic effusive, consisting of phenocrysts of quartz, felspar and hornblende, set in a groundmass of devitrified glass. These are considered to be the surface equivalents of the hypabyssal felspar-porphyries which intrude the rhyolites.

Characteristically the felspar porphyries consist of large phenocrysts of felspar and quartz, set in a finegrained groundmass of quartz, felspar and hornblende. The felspar is usually orthoclase but acid plagioclase also occurs. Quartz phenocrysts almost always show corrosion; to the felspar phenocrysts there is frequently a halo of groundmass, different in optical extinction from the rest of the groundmass but the felspars do not usually show corrosion. Sometimes there is a definite rim of hornblende crystals round the quartz phenocrysts. Biotite is uncommon in these hypabyssal types.

The Undwaria (24° 43′; 72° 47′) suite is more or less continuous with the above, and comprises rhyolites, porphyries and granite; the rhyolites and porphyries show spherulitic growths of felspar, some times around quartz phenocrysts, and graphic intergrowths of quartz and felspar are common. The Undwaria granite resembles that of Isri.

Mr. E. J. Bradshaw, after visiting the cantonment of Bakloh to advise on its protection from landslips, and Ambala in connection with a deep boring for water, commenced field-work in Rajputana on the 15th November 1925.

Mewar, Bundi and Shahpura States; and Ajmer-Merwara district.

Standard sheets Nos. 45 $\frac{O}{2}$, $\frac{O}{3}$, $\frac{O}{6}$, and $\frac{O}{7}$, on the scale of 1 inch to 1 mile (old Nos. Central India and Rajputana 233 and 234) were completely geologically surveyed, this area forming part of the Mewar (Udaipur) State, with portions of the States of Bundi and Shahpura and of the district of Ajmer-Merwara.

The basement formations occupy by far the greater portion of the area, forming a level plain covered by thin soil, with few irregularities diversifying the monotony of its surface. They may for the present be divided into the Gwalior and Aravalli systems with the proviso that the two may be proved to be the same. In the south-east are shales and slates, and a striking absence of calcareous or arenaceous rocks, which are represented only by infrequent and thin beds of gritty, ferruginous quartzite, by greywacke and by lenticular impure limestones.

The strike is uniformly N.E.-S.W., with a cleavage which dips steeply to the N.W. The original dip is usually obliterated, but

where seen, is low and rolling. This shale or slate country weathers into a multitude of low, rounded hills, usually with back bones of intrusive reef-quartz. These are termed "Gwaliors", while the "Aravallis" to the north-west are represented by a fine-grained biotite-gneiss and garnetiferous mica-schist.

A traverse from north-west to south-east in a direction at right angles to the strike might lead to an erroneous conclusion. Starting on biotite-gneiss and passing across a belt of mica-schist with much pegmatite, one comes to a zone of phyllites with garnet and staurolite, mica-schist and slate, all copiously injected with reefs of white vein-quartz. Here there is apparently a very sudden decrease in metamorphism, accentuated by the intervention of the major syncline of the so-called "Jahazpur series." Up to this point the rocks belongs to the "Aravalli" type of formation, but here a change is to be noted to the shales and slates of "Gwalior" type, comparatively unaltered and more sparsely quartz-veined.

The abruptness of the change from mica-schists to shales might here be deemed sufficient to separate "Aravallis" from "Gwaliors" were it not for the fact that if a section at right angles to this, *i.e.*, from N.E. to S.W., say from Tikar to Kajuri, be examined, it will be seen that, as well as a sudden decrease in the degree of metamorphism from N.W. to S.E. across the strike, there is also a steady decrease from N.E. to S.W. along the strike, and the mica-schists and phyllites can be traced into shales and greywackes precisely similar to the rocks of the "Gwalior" type.

The biotite-gneiss which occupies the north-western portion of the area is a fine-textured, grey rock consisting of flakes of fresh biotite with grains of quartz and white felspar, usually finely foliated and never granitoid. Besides the innumerable intrusions of pegmatite in bosses, and the many dykes and sills of amphibolite, the biotite gneiss is often crowded with thin veins of pegmatite, consisting of quartz graphically intergrown with orthoclase and a pink felspar, probably microcline. As the proportion of biotite rises, the gneiss passes imperceptibly into the mica-schist, the dotted boundary shown on the map being arbitrary, for although the extreme forms of the biotite-gneiss and the mica-schist are very different, they cannot be definitely separated where they merge into each other.

Two tongues of the Berach granite (General Report, 1925, *Rec. Geol. Surv. Ind.*, LIX, p. 94) which forms a great expanse in the area to the west mapped by Mr. B. C. Gupta (see p. 118) cross

the western edge of Sheet 234. The oldest rock of the area is probably the dark, sheared Aravalli granite-gneiss exposed at Bileta (25° 35′; 75° 24′) and Etonda (25° 38′; 75° 28′).

The younger series, which may temporarily be called after the town of Jahazpur (25° 37′; 75° 20′) until correlation is possible, lies unconformably upon all of the above formations, and consists essentially of a quartzite below, about 500-700 feet in maximum thickness, and an overlying limestone, 1,000 feet thick as a maximum. The average thicknesses are only about half this and to the south-west the formations become very attenuated. The Jahazpur rocks crop out as two parallel ridge-systems running N.E.-S.W. The north-western is a syncline which is doubled from Jahazpur south-westwards. The south-eastern one is intricately folded, but, viewed broadly, is an anticline. In each case the fold ends to the south-west in a rounded curve from which a narrow process runs on for miles, a peculiar form of folding which often occurs on a small scale, and is characteristic of the area.

At the base of the quartzite there are usually arkose grits, and sometimes conglomerate. The quartzite is homogeneous and structureless, highly sheared and copiously veined with white quartz. Upon the quartzite the limestone lies conformably, but between the two are passage beds which vary considerably along the strike. In places a buff chert may intervene, which probably results from a transference of silica from the quartzite to the limestone. Sometimes the passage beds consist of alternating layers, each a few inches thick, of limestone and quartzite, or of quartzite, limestone and shale. This layered rock is weak, and peculiarly susceptible to shearing, and its failure, on the application of folding, results in the formation of the ferruginous quartz breccia which is a common phase of the passage beds. The limestone itself is a massive rock, usually ferruginous and always copiously injected with thin veins of white quartz. As a rule it is highly metamorphosed, with formation of tremolite and steatite, and though usually fine in texture, may occur locally as a coarse marble.

Sub-Assistant B. C. Gupta during the field-season completed the geological survey of the Central India and Rajputana 1-inch Sheets Nos. 202 and 293, and a small portion of 201. This area is on the great plain of the Mewar State, which lies between the Delhi synclines on the west and the Vindhyan plateau on the east.

Mewar State.

With the exception of thin sub-Recent or Recent deposits such as soil and river alluvium, the whole tract is occupied by formations belonging to the Archæan (Aravalli) and Purana (?) divisions, of which the Archæans occupy by far the larger area.

Two members of the Archæan (Aravalli), biotite-gneiss and the Berach granite (General Report, 1925, *Rec., Geol. Surv. Ind.*, LIX p. 94), between them divide the area into two approximately equal halves, their junction running diagonally across it in a general N.E.-S.W. direction.

The biotite-gneiss is a soft and usually finely foliated rock, and, as the Berach granite is also easily denuded, the junction of the two is almost always concealed by alluvium. No definite evidence of an intrusion of the Berach granite into the biotite gneiss could be found but the total absence of any trace of unconformity conglomerate between them lends support to the view that the granite is intrusive. Bordering the granite, in an indefinite zone 1 to 4 miles wide, is a somewhat finer modification of the gneiss, approaching a schist, in which garnet and staurolite are developed; this, however, can hardly be taken as evidence of contact metamorphism by the granite.

The ancient sedimentaries (? Puranas) have been grouped in two sets. The shales and slates, with bands of highly crystallised quartzite, occurring in the south and south-east of the area, have been provisionally placed in the Gwalior system, while the calcareous and ferruginous rocks, with quartzites, of the Pur-Banera belt in the north-west are almost certainly the same as those which have been described this field season by Mr. E. J. Bradshaw under the temporary name of the "Jahazpur series."

The junction between the Berach granite and the (Gwalior) sedimentaries of the first set, exposed in several sections around Barlias, (25° 13′; 74° 55′) shows a definite band of conglomerate resting upon the granite and underlying the slaty shales; in these cases the evidence of erosion unconformity is indubitable, as in the case of the quartzites near Chitor mentioned last year. (General Report, 1925, *Rec. Geol. Surv. Ind.*, LIX, p. 95). The mode of occurrence of these quartzites and slates is as semi-isolated strips and shreds, or more or less continuous patches and belts upon the granite. Although no case of a vein of granite penetrating the slates was ever seen, its margin is so intricate, and slate and granite are often so involved with each other along their contact that an

intrusive relation would be inferred, were it not for the entire absence of contact metamorphism and the other points just noted, which, in Mr. Gupta's opinion, prove that the Berach granite is a basement upon which the sedimentaries were deposited.

The "Jahazpur series" is an assemblage of highly altered and much disturbed beds, in parallel bands amidst the biotite gneiss; it represents the compressed synclinal cores that have escaped denudation, the intervening anticlines having been removed.

The sequence in the Pur-Banera belt is as follows :—

(4) limestone,
(3) calc-gneiss and ferruginous quartzite,
(2) quartzite,
(1) arkose grits and conglomerate.

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SIX RECENT INDIAN AEROLITES BY G. V. HOBSON, A.R.S.M., D.I.C., B.Sc., *Assistant Superintendent, Geological Survey of India.* (With Plates 1 to 12.)

THE object of this paper is to place on record the known details of the falls, and some petrographical characters, of six recent Indian aerolities. This account was put together whilst the writer occupied the position of Curator to the Geological Survey of India and is based largely on his own work, but partly on the notes of his immediate predecessors in the Curator's chair.

1. The Adhi Kot Aerolite.

On the 1st May 1919, a meteorite fell about one mile south of the village of Adhi Kot, in the Punjab. It was received by the Geological Survey of India and has now been added to the Collection of Meteorites in the Indian Museum, under the name Adhi Kot, its registered number being 278.

Account of the fall.

Information was first received from the Superintendent of Police, Shahpur District, Sargodha, to the effect that an aerolite had fallen within the jurisdiction of Police Station Nurpur, and was in his possession pending instructions as to its disposal. Enclosed were translations of reports from the Police Station, Nurpur. Ram Ditta Mal, the Sub-Inspector at Nurpur, reported that on 1st May 1919, at about 11 a.m., a thundering sound, like gun fire from the sky, was heard; this was followed by a roaring sound like that made by a running train. The sound died away after an interval. The noise was heard by the villagers, most of whom remarked that in the sky volumes of smoke were seen, which abated after a short time. "They came to no conclusion and were thrown into a dismal state" by the occurrence.

Entry No. 9, dated $\frac{\text{3rd May 1919}}{\text{4th May 1919}}$, of Police Station Nurpur runs as follows :—

"At about 8 p.m. one Sabdar Khan, a Lambardar of village Adhi Kot, brought a black stone of about 6 or 7 seers.[1] He stated

[1] About 12 or 14 lbs.

that on the 1st May 1919 at noon a sound from the sky came, which was heard by nearly all the villagers. One named Khuda Yar, son of Khana caste Budhuwala 'Malah' resident of Adhi Kot observed this stone falling from the sky on the ground, which was in his squares of land ; at a mile distance to the south from his village. The stone about 2 or 3 feet forced into the ground and the above-mentioned Khuda Yar has, by digging it, got it out ; which he has brought to the Police Station................"

Further enquiry elicited the fact that the man who found the aerolite, first heard the sound from a north-westerly direction, then immediately overhead, after which the aerolite fell to the south-east from where he was standing.

This fall was recorded in the General Report of the Geological Survey of India for 1919[1].

Location of the fall.

Adhi Kot is a village in the Shahpur District, Punjab. The village (Lat. 32° 6′ ; Long. 71°48′ 30″) lies some 15 miles north of Nurpur, where the fall was heard, and this latter place is 35 miles south-west of the town of Khushab.

General description of the aerolite.

The aerolite, as received by the Geological Survey of India, weighed 4238·8 grammes. It is a complete individual in an excellent state of preservation.

In shape this aerolite approximates very closely to the pear-shaped form. This fact is not brought out very clearly in the plates, which have been taken with a view to showing the surface markings rather than the shape. Plate 1, figure 2 gives a view of the base of the aerolite, which is oval in shape, the longer axis being about $5\frac{1}{4}$ inches, and the shorter axis about 4 inches. The height of the meteorite is about $6\frac{3}{4}$ inches. The front face in Plate 1, fig. 1 is markedly concave, though this is not very apparent in the photograph. The left-hand side of Plate 1, fig. 1 shows a departure from the pear shaped form, in that it is decidedly convex. Nevertheless this aerolite is essentially of pear-shaped form in which the thin upper end, as seen in Plate 1, fig. 1, has been bent over in the direction of the observer. Farrington[2] states that, as far as known, only iron meteorites exhibit this shape. The Adhi Kot meteorite is, however, a stony meteorite.

[1] *Rec. Geol. Surv. India*, Vol. LI, p. 7.
[2] Meteorites. Chicago., 1915, p. 70.

The thick end shown in Plate 1, fig. 2, has in it a shallow depression, with the deepest point located almost centrally, as can be seen in the photograph. This plate also shows very clearly the smooth crust covering a large part of the base. The crust and a thin layer of the outer part of the aerolite have scaled off at various places, as can be seen in the photograph. Actually there is very little difference between the crust and the interior, but the photographs bring out the differences of texture very clearly. The central part of the surface seen in Plate 1, fig. 1, is almost entirely crust-covered with the crust scaled off all round the margin. The face seen in Plate 2, fig. 1, is devoid of crust except for a small triangular patch at the top, a patch running down the right side and connected with the crust over the depression at the right lower centre, and a patch round the depression in the bottom left-hand corner.

As stated above, the crust is comparatively smooth and is covered with a net-like pattern marked by black lines contrasting with the surrounding colour. This pattern is more apparent on the face seen in Plate 1, fig. 1, than elsewhere.

When first received the aerolite was dark grey to black in colour, but in the damp climate of Calcutta considerable change has taken place, due to the formation of rust, so that the general colour of the aerolite is now a dark bronze grey.

In addition to the almost central depression in the broad end of the aerolite, the crust-covered surfaces show two groups of shallow depressions or "thumb marks"; one group is seen in the right centre of Plate 1, fig. 1, another group in the right centre of Plate 2, fig. 1, and an isolated depression in the bottom left hand corner of Plate 2, fig. 1. The crust shows no sign of flow lines to indicate the orientation of the aerolite during flight.

The fracture faces show a number of slickensided surfaces, two of which are seen towards the upper part of Plate 2, fig. 1. One of these runs horizontally, a quarter of an inch below the V of crust at the top; the other is below, on the left and runs north-east to south-west across the plate. A third such surface is hidden in the deep shadow below. These surfaces do not appear different from the rest of the fracture faces, but they run fairly straight and are finely grooved. At one place, the fused trace of one of these surfaces can be followed on the crust of the aerolite.

A small fragment of the aerolite was broken off for the preparation of a microscope slide and the fresh surface thus exposed was seen to be dark steel grey in colour with numerous bright specks of nickel-iron showing. The surface was very finely granular in texture. This fracture also exposed a small slickensided surface, but without yielding additional information of value.

Specific gravity.

The specific gravity of the aerolite has been determined by hydrostatic weighing to be 3·75.

Microscopic characters.

The micro-slides of this aerolite are almost entirely opaque, with a little clear glass and in one slide a comparatively large, irregular patch of cloudy brown glass. There are also numerous minute crystals of a highly double refractory mineral, possibly olivine.

By reflected light numerous large patches of a silvery mineral (nickel-iron) are seen, intergrown with the black opaque mineral forming the ground mass. There is no trace of chondritic structure in the slides, neither can any appearance of such structure be observed in the mass of the aerolite.

One slide shows a minute hair-like vein running across the field, one end being marked by a thin line of nickel-iron, the other by a black line in the prevailing dark colour.

II. The Atarra Aerolite.

On the 23rd December 1920, a meteorite fell near Atarra, in the United Provinces. Three fragments, of which one was broken into two pieces, were recovered and sent to the Geological Survey of India. These pieces have now been incorporated in the Meteorite Collection, in the Indian Museum, under the name of Atarra, the registered numbers being 280A, 280B, and 280C, respectively. This fall was recorded in the General Report of the Geological Survey of India for 1921[1].

Account of the fall.

The following report was received through the Collector, Banda district, United Provinces, from the Tahsildar of Badausa.

"I beg to report that I heard some two or three sounds like those of big guns in the sky on the 23rd December 1920 at about 5-45 p.m. The sounds were followed by heavy thundering and I saw a long row

[1] *Rec. Geol. Surv. Ind.*, Vol. LIV, p. 10.

I 2

of white smoke. People thought that some airship passed. However now I heard that some stones fell near Turra on the same day. I sent for them and received three pieces..........."

The Collector in forwarding this report gave the following account of his own experiences :—

"......I myself was at Bara Muafi in camp and this meteorite came to my attention while I was sitting in court. My peon Shemarain called my attention to what he said was a "bursting star". I went out and saw in the heavens, almost directly overhead, a long white trail of smoke such as is left by a rocket. It travelled almost direct from north to south, with a slight divergence, say 10° to west of north. Bara Muafi is midway between Harkundi and Manikpur railway stations to the south of the railway. The white smoke seemed to me, as well as I could judge, between one and two miles high and the trail covered miles and lasted some minutes gradually curling and disappearing. It was about 5-35 p. m. on 23-12-20......The smoke was white against a blue sky. Accompanied by thundering sound but I did not hear it ; said to be like a motor in the distance........"

This aerolite has been named after the town of Atarra in Banda district, United Provinces, (Lat. 25° 17′; long. 80° 34′ 20″) but the fall actually occurred at the village of Turra (Lat. 25° 15′ 15″; long. 80° 37′ 30″) situated four miles south-east of Atarra or two miles north-west of Badausa.

Location of the fall.

General description of the aerolite.

As already mentioned, three pieces of this aerolite were recoverd and forwarded to the Geological Survey of India ; the weights of the pieces as received being as follows :—

		Grammes.
280A		590·98
280B		464·93
280C	(i)	145·54
	(ii)	78·47

The third piece was fractured and is now in two pieces, the weights being as given above. The piece, No. 280C (*i*) has since been presented to the British Museum.

Fragment 280A, seen on the right in Plate 2, is a portion of a larger piece, which was probably roughly pyramidal, but is now

cut off at the top and bottom by two fractures, inclined towards one another at a small angle. The remaining faces are covered, for the most part, by a crust, which is black in colour, fairly thick and finely scoriaceous with projecting points ; these latter are often bright where nickel-iron shows through. The fractured surfaces are dark in colour and, in certain cases, this is enhanced by partial refusion after fracture, but the comparatively fresh break across fragment 280C shows the same dark colour, which is evidently characteristic of the stone as a whole. The surfaces on 280A do not appear to have suffered much from refusion.

The fragment is 11 cms. along its major axis, by 7 cms. along the minor axis, and 5·5 cms. in depth.

Chondritic structure is not very apparent to the naked eye or under an ordinary lens, but there is one chondrus towards the centre and 2 cms. from the broad end of the larger fracture surface, seen in Plate 3, fig. 1, that has not broken with the matrix and is seen standing out like a half-embedded shot. This chondrus is about 1·4 mm. in diameter. In one corner of the smaller fractured face, seen at the top right-hand corner of Plate 2, fig. 2, there is a large chondrus that has not broken with the matrix and projects out of the mass. The top surface of this has been fractured off, but the whole is clearly seen to be a partially exposed chondrus about 6 mm. in diameter.

The fracture surfaces show the presence of nickel-iron in bright silvery patches of irregular shape and also two quite large patches of troilite. One large patch of the former is clearly seen as a bright marking rather to the right of the centre of the fragment in Plate 3, fig. 1. The latter are irregular in shape ; one is near the large chondrus above described, and runs from the outside for 8 mm., like a vein, up to 1·5 mm. in thickness and showing steel grey to blue and bronze-purple tarnish colours near the crust. The other patch occurs on the larger fracture surface, to one side of a surface depression, which the fracture has bisected, seen in the upper right hand edge in Plate 3, fig. 1. Here the troilite appears to occur as the outer portion of a poorly developed chondrus, 8·5 mm. in diameter, and having a silicate mineral as the central core. Troilite also occurs as an irregular extension on one side of this chondrus. Here again there is slight evidence of tarnish colours where the troilite is adjacent to the crust. In both cases the mineral is normally of a dull bronze-yellow colour with a hackly fracture.

Fragment 280B is irregularly rhombohedral in shape with original crustal surfaces on four sides, a fractured surface on one side and the other side covered with a secondary crust due to refusion after fracture. The original crust on the largest surface (see left hand fragment in Plate 3, fig. 1) is almost smooth and of a reddish brown to chocolate colour. The remaining portions of original crust are black and finely scoriaceous resembling the crust of fragment A. The secondary crust is also black in colour, but it is thinner. It appears almost polished in places and in others distinctly slaggy; this is seen on the left-hand fragment in Plate 2, fig. 2.

Many of the more angular parts of the fragment have had the crust and a thin layer of the interior scaled off, and as already stated one side is a fracture face. The fracture surfaces are dark in colour resembling those of fragment A.

Chondritic structure is not apparent to the naked eye or with an ordinary lens. At one end of the main fracture face, however, there is a circular patch, which appears to be a chondrus, about 2·5 mm. in diameter, of a pale buff colour but with an all defined margin.

At the broad end the fracture surface has cut through a surface depression, seen as the top left-hand corner in Plate 3, fig. 1, the deepest point of which marks a patch of bronzy troilite running down into the mass of the aerolite, much like a short, thick vein. This shows the same surface tarnish colours and the hackly fracture of the troilite in fragment A.

Fragment 280C is now in two pieces, one of which, as already stated, is in the British Museum. The portion with the Geological Survey of India has two crust covered sides practically at right angles to one another, seen at the top and right-hand side of the central piece in Plate 2, fig. 2; at right angles again the third side is a fracture side, as is also the fourth side, which runs obliquely as shown in the photograph. The upper surface, Plate 2, fig. 2, is partly covered with original crust, clearly seen in the lower part of the photograph; below this again is a small freshly fractured surface. The remainder is covered with incipient crust due to secondary fusion after fracture. The lower surface, Plate 3, fig. 1, is the fracture surface against which fits the fragment now in the British Museum.

The original crust is a black, scoriaceous crust similar to that on fragment A, whilst the secondary crust is hardly more than a dis-

colouration of the fracture surface and this fracture evidently occurred late in the flight of the aerolite.

The fracture faces of this fragment are very dark in colour, being a little darker even than similar faces in fragments A and B. The fractures are sprinkled with silvery specks of nickel-iron and bronzy patches of troilite ; the surface described as the lower fracture face being particularly rich in metallic particles. As a whole these surfaces do not indicate a chondritic structure, but at the top of the edge between the two fracture sides there is a hemispherical depression, which is evidently the cast of a chondrule, nearly 4 mm. in diameter, that has broken clear of the matrix and is now missing.

One of the fracture sides exposes a line along which the aerolite tends to fracture and from the small portion of one side of this line, which is exposed, it appears to be a slickensided surface. The large basal fracture face is roughly parallel to this line and, though the surface is rough and irregular, some portions of it give indications of slickensiding.

Specific gravity.

The specific gravity of the pieces has been determined by hydrostatic weighing to be as follows :—

	Sp. gr.
280A	3·48
280B	3·52
280C (ii)	3·44

Microscopic characters.

In thin sections the structure of this aerolite is seen to be almost entirely chondritic, see Plate 3, figs. 2 and 3, the chondri in the slides varying in size up to a maximum diameter of 1·4 mm. Olivine and enstatite, in about equal proportions, are the principal silicate minerals present. The olivine is found in the familiar polysomatic and ribbed chondri. The enstatite, chondri of which are perhaps more abundant than of the former, builds the usual fanlike radiating structures. Some of these are incomplete or mis-shapen, whilst others are dense, when the radiating structure is hardly visible. One chondrus, seen in the lower left-hand quadrant in Plate 3, fig. 3, consists of about one third of fibrous enstatite, one third granular enstatite and one third olivine. Intergrowths of enstatite and olivine, forming a mosaic, build up certain chondri. Nickel-iron and the metallic sulphide do not form

chondri but occur as irregularly disposed particles in the interstices between the chondri. The greater part of the opaque mineral in the microphotographs is nickel-iron with some troilite.

The groundmass is seen to consist of a confused aggregate of olivine and enstatite grains and particles. Some of the olivine grains are much larger than the average and though tending to show crystal outline the majority have very irregular boundaries. The grains as a whole are much fissured but are clear and free from clouding and inclusions.

Classification.

The writer has compared this aerolite with others in the Meteorite Collection in the Indian Museum, and it is very similar in outward appearance to the Sultanpur fall described by H. Walker.[1]

In the absence of any chemical analysis the writer proposes to classify this aerolite as: Stone, No. 25, Black Chondrite, Cs of Brezina.

III. The Haripura Aerolite.

This aerolite presents many unusual features and for a complete description and classification of the fall a thorough investigation and particularly a chemical analysis is called for. It has been found impossible to carry out this work up to the present, but it appears desirable to place on record the known details of the fall, together with a description of the external appearance, without any delay and this the writer has attempted to do herein.

At 9 p.m., on the 17th January 1921, two pieces of an aerolite fell at the village of Haripura, in the Jaipur State. Through the courtesy of the Jaipur Durbar, one of these pieces was presented to the Geological Survey of India and has been incorporated in the Meteorite Collection, in the Indian Museum, under the name Haripura, its registered number being 281. This piece is the subject of the description herein, the second piece is exhibited in the Museum, Jaipur, Rajputana.

Account of the fall.

The following is the story of the fall as collected by Rai D. L. Khanka Bahadur :—

"I beg to state that I have got two pieces, resembling stone, having black colour and they are reported to have fallen from above

[1] *Rec. Geol. Surv. Ind.*, Vol. LV, pp. 133-135.

in a village Haripura in the Jaipur State. Before they fell at about 9 p.m., on 17th January 1921, it is said that there appeared a flash of light in the sky followed by loud sounds like that of gunfire and drum beating successively and a lull ensued and then a fall of some material substance was apprehended and only two pieces of stones were found there after search.........."

Further enquiries elicited the additional information that the meteorite was found, where it fell, in two pieces. It seemed to have been broken by the fall and not by human agency. The meteorite penetrated about nine inches into the ground and when taken out was cold.

Location of the fall.

The aerolite fell at the village of Haripura in Shekhawati (Nizamat Jhunjhum) Jaipur State: this village being near Police Station Pilod (Lat. 28° 22′ 30″; long. 75° 46′ 30″).

General description of the aerolite.

The fragment of this aerolite that was received by the Geological Survey of India weighed 315·15 grammes, and there were some small fragments, broken off in transit to Calcutta, weighing 0·27 grammes, so that the total weight received was 315·42 grammes. The small pieces have been used in the preparation of micro-sections.

The aerolite is extremely fragile and since its arrival in Calcutta it has been accidentally broken into two pieces along the major crack seen in Plate 4, fig. 1.

In shape the aerolite is roughly rectangular as seen in Plate 4, fig. 1, and tapers slightly in thickness from left to right in this photograph. As can be seen the upper surface is covered with crust whilst the lower surface is due to fracture; this latter is seen on the left side of Plate 4, fig. 2. The side to the left of Plate 4, fig. 1, seen also in fig. 2 at the bottom, is entirely crust covered. The side at the top of the Plate 4, fig. 1, seen also in fig. 2, is almost covered by crust there being a fracture face at one corner only. The remaining faces are fractured surfaces.

The crust is estimated to have a thickness of 0·5 to 1·0 mm : owing to its extreme fragility it has been found impossible to obtain a micro-section of the crust from which to make actual measurements. This crust consists of small blobs and stringers of fused, black material on a background of reddish brown, finely scoriaceous material. At the corners and edges fusion has been much more complete and the

slaggy looking crust shows incipient lines of flow, though without giving any clue as to the orientation of the fragment during its flight.

As is clearly seen in the Plates there is a major crack, which cuts the fragment into two approximately equal pieces, penetrating both the crust and the main body of the aerolite. In Plate 4, fig. 2, two other cracks may be seen running approximately at right angles to the major crack. The body of the fragment is traversed by several other cracks in all directions, which do not show in the photographs and do not emerge at a crustal surface. In addition to these main cracks the crust of the aerolite is divided up by a regular network of minor cracks, which are very clearly seen in the photographs. These cracks resemble the shrinkage cracks observed in a clay, which has dried out in the sun, and they are possibly shrinkage cracks formed during the final setting of the crust.

The fracture surfaces show a graphitic lustre, particularly on the projecting portions. This may be due to incipient secondary fusion, but the writer regards it as due to rubbing and polishing during transit to Calcutta. The material of the aerolite can be readily cut with a knife and is soft enough to leave a black mark on paper so that such polishing may easily have occurred.

The more recent fractures show a dull black surface with white, grey and rust brown spots up to 1 mm. in diameter. Examined under a lens these specks appear just like the vesicles in a volcanic rock, filled for the most part with a white crystalline mineral. Some of these, however, are perfectly round like chondri and one shows very clearly the barred structure of what is probably an olivine chondrus, with two sets of bars almost at right angles to one another. Specks of nickel-iron can also be detected in the groundmass.

Specific gravity.

The specific gravity as determined by hydrostatic weighing, using a 19 gramme fragment of the aerolite, was 2·76. Two small particles tested by the immersion method gave a result of 2·791, whilst a third and larger particle gave 2·704.

Microscopic characters.

An examination of thin sections of this aerolite show that it consists largerly of an opaque groundmass. This groundmass is black in colour and probably carbonaceous, but until the aerolite has been analysed it is impossible to be certain on this point.

Within this groundmass are chondri of granular olivine and a number of scattered minute crystals of the same mineral. In one slide a fairly large chondrus of nickel-iron can be seen whilst in another there are some minute occurrences of a transparent mineral suggesting a rhombohedral carbonate such as calcite; further work is required, however, before the presence of this mineral in the aerolite can be taken as established.

Owing to its extreme fragility it has been found impossible to obtain micro-sections of the crust, which has, therefore, not been microscopically examined.

Classification.

As stated at the begining of this description, it is necessary that a chemical analysis and some further investigation as to the composition of this aerolite be made before it is possible definitely to classify the fall. As a purely tentative suggestion, for the purpose of allocating a place in the collection for this aerolite, the writer proposes to place this fall in the class: Stone, No. 28, Carbonaceous Chondrite, (K) of Brezina.

IV. The Shikarpur Aerolite.

On the 9th August, 1921, a meteorite fell in the neighbourhood of Deari Shikarpur, a village in Bihar and Orissa. One piece was received by the Geological Survey of India and registered in the Meteorite Collection, in the Indian Museum, under the name "Shikarpur" and number 282. The fall was recorded in the General Report for 1921[1], but at that time the name of the actual village in which the meteorite fell was not known. Subsequent information was received that the fall took place at Deari Shikarpur and, in accordance with general custom in the naming of aerolites, this fall was named Shikarpur.

Account of the fall.

The first information received of this fall was through the following enquiry in the Calcutta "*Statesman*" of 21st August 1921, under the heading "*Notes and Queries*":—

Meteorites.—I would like to enquire through the medium of your esteemed paper whether there is any society or institution that takes an interest in meteorites. A piece of stone, about 6 inch by 5 inch, by 3 inch, weighing about 8 lbs., recently fell in a paddy field near a village in this district and has been brought to me. The people say that the fall was preceded by a hissing noise, first from south to north

[1] *Rec. Geol. Surv. Ind.*, Vol. LIV, p. 10.

and then from north to south. It took place at about 9 in the morning of the 9th current. Possibly it is a fragment of the tail of the comet through which we have recently been passing. I do not know whether the stone would be of any scientific interest, but if so, I would be pleased to forward it could any of your readers inform me where to send it."

It was ascertained that the writer of the above paragraph was Mr. E. Ll. Marriott, Superintendent of Police, Purnea. In forwarding the aerolite to Calcutta, in response to the request to forward the same to the Geological Survey of India, Mr. Marriott wrote that unfortunately the persons best able to give information regarding the fall were concealing themselves, for the reason that they were mixed up in a criminal case, and the only additional information available was as follows.

There appear to have been no fragments. The large stone sent being all that was found. The fall occurred in the day time and no information as to light phenomena was obtainable. The meteorite, as stated, was found in a rice field, having penetrated sixteen inches into the soil. The stone was said, by the villagers, to be hot when picked up and to smell of gunpowder. The fall was accompanied by a sound which they described as being like the explosion of a gun.

Location of the fall.

The aerolite fell into a paddy field within the limit of the village of Deari Shikarpur, Police Station Kasba, District Purnea, in the province of Bihar and Orissa, (Lat. 25° 51′; long. 87° 34′ 39″).

General description of the aerolite.

The aerolite received by the Geological Survey of India, is a single piece 3,679·7 grammes in weight.

This piece is almost a complete individual with three small fracture surfaces occurring at angular points of the aerolite, as seen in Plate 5, fig. 2. The shape of the stone, as may be seen from the photographs, is roughly that of an irregular pentagon with a flattened surface above and below: the thickness is greatest at the bottom right-hand corner in Plate 5, fig. 2, and diminishes slightly towards the shoulder near the top left hand side where it is bevelled off fairly sharply, the whole giving the appearance of a very blunt wedge.

There are no lines of flow visible, on the crust of this aerolite, to indicate its orientation during flight; but the writer considers that the apex in Plate 5, fig. 2, was the foremost point during flight and that the shoulders on each side were probably fractured off on impact with the earth. Also this end is cracked to a certain extent

while the other end is not suggesting that this end received the blow of the impact with the earth.

With the exception of the three fracture surfaces mentioned above, the whole aerolite is covered with a very finely scoriaceous crust. This crust is quite thick and well defined in relation to the interior. The general colour of the crust is fairly dark grey, but in certain places, notably the apex and most of the front face in Plate 5, fig. 1, it is much darker, and the true colour of the crust appears to be almost black, the grey colour being due to terrestrial mud adhering to the crust.

For the most part the surface of the aerolite is smoothly undulating, but at the left hand upper side of Plate 5, fig. 2, there occurs a relatively deep depression the bottom of which is marked by three small holes joined by a crack running the length of the depression. These holes are quite deep for their size and can be readily seen in the photograph. They are comparable with the depressions in the Merua meteorite[2], but on a much smaller scale.

There occur on the crust numerous black shiny patches of varying size up to 5 mm. in diameter and of roughly circular shape. These appear to be the fused traces of chondri, which have been cut through and the sections of chondri have fused more readily and produced a more glazed finish than the rest of the crust. There are occurrences of what are taken to be nickel-iron, projecting through the crust and partially fused.

The crustal surface is marked by some very fine lines : these are the fused traces of slickensided surfaces and can be seen passing into the latter on one of the fresh fracture surfaces. One such line can be seen traversing the lower margin of a shallow depression or " thumb mark " towards the upper part of Plate 5, fig. 2. Another line commences on the centre line of Plate 6, fig 1, a quarter of the way up from the base and running to the right and upwards, passes round the extreme right-hand point, crosses the bottom of the fracture here and continues to the centre of Plate 5, fig. 2, where it very nearly meets the line already described. The fracture surface at the bottom left hand corner of Plate 5, fig. 2, has a single fine thread-like vein running across it. The surface above this has a network of these fine veins traversing it in all directions. The surface at the top of Plate 6, fig. 1, has several of these lines or veins and in parti-

[1] *Rec. Geol. Surv. Ind.*, Vol. LVI, p. 348.

cular shows a larger slickensided surface, of which Plate 6, fig. 2 is an enlarged view. This face is 13 mm. by 17 mm. and passes into the unfractured port on of the stone. The face appears comparatively flat to the naked eye but, when examined by means of a lens, is seen to be grooved. This face, in common with other small exposures of a similar nature, is covered with a polished metallic skin and appears to be similar in every respect to faces on the Merua meteorite.[1]

The general colour of the fresh fractures is very light bluey grey with some rusty patches, doubtless due to the action of the damp climate of Calcutta. Shining specks are visible to the naked eye and, with a lens, these are seen to be white metallic points of nickel-iron and bronze patches of troilite, scattered irregularly through the mass. Chondri are not very apparent, but examples can be seen with a lens and these break with the matrix.

Specific gravity. The specific gravity has been determined by hydrostatic weighing to be 3·60.

Microscopic characters. In thin sections under the microscope the crust of this aerolite is seen to be non-homogeneous, having patches of unfused nickel-iron in it and containing olivine irregularly distributed through it. The crust is a thick one, up to 0·7 mm., and the inner surface is irregular. The crust is not divided up into zones such as are often observed.

There is one large, ill formed, chondrus of a fibrous, cloudy mineral probably enstatite. There are also numerous well rounded chondri of olivine, some of which contain inclusions of an opaque mineral. The matrix consists mainly of granular olivine and some enstatite with a little oligoclase ? and irregularly distributed patches of nickel-iron and troilite. The thread-like veins are seen to consist partly of nickel-iron and partly of an opaque, black mineral without metallic lustre. The opaque mineral in the slide is mainly nickel-iron and troilite, but the slide also is dotted with specks of a black, opaque mineral, without metallic lustre by reflected light, and this may possibly be carbonaceous matter.

Classification. The writer has compared this aerolite with others in the Meteorite Collection, in the Indian Museum, and it bears quite a striking resemblance, in many respects, to the Kuttipuram aerolite described by Dr. Coggin Brown[2] both in outward appearance and also microscopically.

[1] *Rec. Geol. Surv. Ind.*, Vol. LVI, pp. 347-348.
[2] *Rec. Geol. Surv. Ind.*, Vol. XLV, p. 209, *et seq.*

In the absence of any chemical analysis of the aerolite, the writer proposes to classify this as : Stone, No. 15, Veined White Chondrite, (Cwa) of Brezina.

V. The Muraid Aerolite.

On the 7th August, 1924, a meteorite was reported to have fallen in the neighbourhood of Gupta Brindaban at 2-30 p.m., and subsequently pieces were recovered from the villages of Muraid and Mantala ; these have been added to the Meteorite Collection, in the Indian Museum, under the name of Muraid, the registered number being 290A and 290B.

The following is an account that appeared in " The Bengalee " of Friday, 5th September, 1924, under the heading " Is it a Meteor ? Curious Phenomenon near Mymensingh." " A curious phenomenon was observed on the 7th August last in the neighbourhood of Gupta Brindaban, a place of pleasant scenery inside the forest known here as the Madhupur Garh. At about 2-30 p.m., on that day a continuous whizzing sound followed by three successive reports resembling the booming of gun was heard. One Babu Jadobraj Pal Chowdhury an officer of Mr. Guznavi was there at the time in connection with his official business. He told me that he himself heard the sound. He was told that pieces of stone had fallen from the sky at that time. He himself went out and found in three different places three pieces of a stone like substance of gunmetal colour and in size of a cocoanut. The surface of these unknown substance was highly polished and they were found embedded in earth. These pieces are now with some headmen of villages belonging to Mr. Guznavi, the ex-Minister.........."

Account of the fall.

When this report came to the notice of the Geological Survey of India, a request was sent to the local officials to obtain possession of the fragments. The Indian regards such manifestations with great veneration and such fragments often become the object of public worship and are so lost to science, unless prompt action is taken to obtain them.

As a result of the enquiries made it was found that two fragments of the aerolite had been recovered, one from the village of Muraid and one from Montala. These were in the possession of Mr. Guznavi who, on being approached by an officer of the Geological Survey, kindly presented the pieces to the Indian Museum. All trace of the third fragment, mentioned in the original report, has been lost.

Location of the fall.

The aerolite fell in the Ghatail sub-division of the Mymensingh District, Bengal, one piece being recovered from the village of Muraid (Lat. 24° 29′ 40″; long. 90° 13′ 5″), and another piece from the village of Mantala (Lat. 24° 29′ 25″; long. 90° 12′ 20″) the latter village being approximately one mile south-west of the former. In accordance with usual custom in the naming of meteorites this fall has been given the name of one of the villages from which material was actually recovered.

General description of the aerolite.

The two fragments received by the Geological Survey of India, are portions of one stone and together are almost complete, there being only a small amount missing at one end this fracture surface being clearly seen in Plate 10, fig. 1, whilst some minor chipping of the edges is seen in Plate 9, figs. 1 & 2.

As noticed first by Dr. Pascoe, this aerolite is of exceptional interest owing to the fact that the two pieces, recovered from villages a mile apart, fit together to form a whole and the two faces of the fracture have become covered with a secondary crust showing that the fracture must have occurred at a considerable height above the earth. In spite of this secondary crust the two faces fit together without leaving any doubt on the point. Plate 7, fig. 1, shows the two pieces fitted together, but the photograph rather exaggerates the rounding of the two surfaces. Fig. 2 shows the two pieces in the same relative position but drawn somewhat apart to show the break.

The aerolite has an irregular egg shape, somewhat flattened on the side on which it is resting in Plate 7.

Original crust covers the aerolite with the exception of the fresh fracture surface at one end and the surfaces with secondary crust at the break. This original crust is comparatively smooth and polished, but there are well developed flow lines on it, which when examined with a lens, are seen to be irregular ridges of material that has been more or less melted. The colour of the original crust varies from black to a gun-metal colour, whilst the lower part of the rounded surface at the end, *i.e.*, the lower left-hand surface in Plate 10, fig. 2, is of a decided reddish brown colour. A somewhat similar colour is to be seen at the other end adjacent to the freshly fractured surface. The whole surface is marked with pinpoints and fine lines of a dirty grey colour and also patches up to $\frac{1}{4}$ inch in diameter of a pale brown colour, all of which are due to the adhesion of terrestrial material.

There are certain characteristic patches, which have taken a glaze possibly owing to the greater degree of fusion of the material at these points; many of these patches are quite circular and may well be fused traces of chondri.

The smaller fragment has several irregular projections in the crust which are possibly pieces of nickel-iron, as these are similar to an occurrence in the secondary crust to be described later.

Except for three depressions which are so small as to be negligible the surface of the smaller of the two pieces is quite smooth. This is not the case with the larger piece of which the surface is pitted with the "thumb marks" so characteristic of stony meteorites. Two of these are fairly deep in comparison with their area and are well seen in Plate 7. The remainder are quite shallow, being more in the nature of undulations.

The crust on the end adjacent to the fresh fracture (see lower part of Plate 10, fig. 1) differs to a slight extent from the original crust on the other surfaces, but, in the writer's opinion, this also is original crust, the chief difference being the absence of flow lines which are so marked a feature of the other surfaces of original crust.

Turning now to the secondary crust on the two faces of the break in the stone, the general appearance of these two faces is very well shown in Plate 9, figs. 1 & 2. The face of the smaller piece (Plate 9, fig. 1) is black in colour except where it is contaminated with terrestrial matter. The surface is a matte one with some shiny specks and patches. The form of this surface is almost botryoidal as may be seen in the photograph. In the photograph can also be seen the very marked projection of nickel-iron through the crust, which has already been mentioned. This is seen half-an-inch north-west of the small fresh fracture at the extreme right-hand side. There are two pieces of metal sticking up in a small crater and coated for the most part with a black crust. The point of one piece is not, however, crust-covered and shows a metallic lustre with a slightly brassy colour. The writer considers this to be nickel-iron and not troilite, the slightly yellow colour being due to tarnish.

The face on the other side of the break is similar, except that it is a cast of the former and the irregularities of this surface appear to have been smoothed out rather more by the fusion subsequent to the break. The face is well shown in Plate 9, fig. 2, which, however, throws the irregularities up in somewhat exaggerated relief.

As already mentioned this aerolite evidently broke at a great height and the faces of the fracture became coated with secondary crust, which does not, however, mask the fact that the two faces fit together exactly. A second very striking feature of this aerolite is the flow structure, which has been developed by the passage of the stone through the terrestrial atmosphere and which, together with the above facts, clearly demonstrates the history of the aerolite during its fall.

Flow structure.

Plate 8, fig. 1, shows the lines of flow which were evidently produced in the early stages of the flight, before the stone broke into two pieces. In the plate the lines can be traced from the toe of the aerelite in a backward and upward direction to the main break. On the aerolite itself these lines can be traced across the break on to the shoulder, along the break, on the larger piece. These then are the primary lines of flow, produced when the stone was a single entity and showing that the stone as a whole fell with the toe forward and the larger mass of the stone to the rear, as is commonly the case with stony meteorites.

Plate 7 shows with the greatest clearness the secondary lines of flow produced in the original crust of the larger piece, running from the bottom corner at the break, in an upward and backward direction. Exactly similar lines can be seen on the other side and at the back, all starting from the same corner of the fragment and spreading out, fan-like towards the fresh fracture at the top of the rear face. Similarly flow lines are clearly seen in the secondary crust of the face of the break showing that these lines were produced in the later stages of the flight. These lines are clearly seen in Plate 9, fig. 2, where the point of common origin is here at the top and the lines fan outwards and downwards.

All these secondary lines of flow, both in the original crust and the secondary crust, show that when the stone broke, the rearward portion so altered its orientation in flight that the top point in Plate 9, fig. 2, which is the bottom left hand point in Plate 7, fig. 1, became the foremost point during the independent flight of this fragment. As a result of the fracture this rear portion became a flat sided cone of which the apex took the lead during its flight.

In the case of the smaller portion, the secondary lines of flow are not so well marked, but are still sufficiently distinct to decide the orientation of this fragment during its independent flight. Such lines occur on the face forming the right-hand side of Plate 10, fig.

2, and though they can hardly be distinguished they run from the top towards the bottom. Similar lines occur on the shoulder between the flattened surfaces on the left-hand side of the photograph. The lines in the secondary crust are not at all clear, but are sufficiently defined to show lines radiating from the top point downwards. These all show that the top point in Plate 9, fig. 1, which is the bottom right hand point in Plate 7, fig. 1, took the lead during the independent flight of the smaller portion.

As further proof, if such proof were necessary, it can be seen that during the independent flight of the two fragments, material on the freshly fracture faces was partly melted and by the force of the air pressure was made to flow back over the face and actually overlap the edge further back during flight. Thus the lower edge in Plate 9, fig. 1, shows a well marked burr where material has flowed back, during the secondary fusion, and has truned over on to the outer surface, which was evidently protected, by the original crust, from the same degree of fusion. The same thing is seen along the lower edge in Plate 9, fig. 2, that is on the larger piece, but not to quite the same degree as on the smaller piece.

It is now possible to reconstruct the history of the flight of this aerolite taking Plate 7, fig. 2, as the guide. The stone entered the terrestrial atmosphere as a single individual and during this period of its flight, the rounded and somewhat tapered portion was leading with the more massive irregular portion behind. Thus the direction of flight of the stone as a whole was from right to left as seen in Plate 7, fig. 1, along the diagonal. This flight was of sufficient duration to produce lines of flow in the primary crust. At a certain stage in its flight the aerolite burst into two pieces along a plane practically at right angles to its direction of flight and at a point rather less than half way from the forward end, thereby splitting the stone into a smaller portion to the front and a larger portion behind.

This smaller portion made nearly a quarter turn parallel to the plane of flight and thus brought the point seen at the bottom of the break in Plate 7, fig. 2, to the front, and the fragment continued its individual flight with this orientation. This individual flight was of sufficient duration for the formation of a secondary crust on the freshly fractured face, for the production of lines of flow in this crust and also in the original crust and for the .low of semi-molten material across the fresh fracture towards the rear, and to the extent of overlapping the edge.

The larger piece also made a partial turn in the plane of flight, not to the same extent as the smaller piece but sufficient to bring the point at the bottom of the break, in Plate 7, fig. 2, to the front and the fragment continued its independent flight with this orientation and with the production of similar phenomena as on the smaller piece.

Finally the two pieces struck the earth at points about one mile apart as already mentioned. Unfortunately no information is recorded as to which piece fell at which particular village, as otherwise the actual direction of flight could be decided since the larger piece would travel further.

The respective weights of these pieces as received by the Geological Survey are :—

	Grammes.
290 A	2925·67
290 B	1777·59

Internal structure.

Examination of the freshly fracture surfaces shows the interior of the aerolite to be of a very light, bluey grey colour, which on exposure becomes slightly darker and dull in appearance, whilst small rusty looking patches have developed, doubtless due to the damp atmosphere of Calcutta.

To the naked eye there are visible numerous shining metallic specks and, when viewed through a lens, the surface is seen to be plentifully sprinkled with small pieces of nickel-iron of the characteristic tin white colour and occurring as isolated specks and in small aggregates. Slight traces of a bronze-coloured metallic mineral (troilite) can be observed.

Chondritic structure is not very apparent, but there is some evidence of the presence of small chondri breaking with the matrix or projecting as unbroken entities.

The large freshly-fracture face gives a cross section of the original crust, which is seen to be somewhat variable in thickness up to 0·5 mm ; it is black in colour and well distinguished from the pale coloured interior. The chipped corner of the smaller fragment gives a cross section of both the primary and secondary crusts and the latter is seen to be distinctly thinner than the former and though well marked from the interior of the aerolite, it is not so well defined as the original crust.

Specific gravity.

The specific gravity of the aerolite as determined by hydrostatic weighing is as follows :—

290 A	3·57
290 B	3·55

Microscopic characters.

Examination of thin slices of this aerolite shows that it is a chondrite, but one in which the chondritic structure is not at all well developed. The majority of the material is in the form of an aggregate of olivine and enstatite with a small quantity of an interstitial mineral, which gives pale grey polarization colours, is biaxial and negative with a refractive index slightly below that of the Canada Balsam of the slide, which the writer regards as oligoclase. In addition to the above silicate minerals there are irregularly dispersed patches of nickel-iron and a few specks of troilite. One small patch of troilite entirely surrounds a crystal of enstatite. There are a few specks of black opaque mineral which shows no metallic lustre by reflected light and may possibly be carbonaceous matter. No glass can be seen.

A thin section of the original crust shows this to have a thickness of about 0·4 mm. downwards and to consist of three zones. The outer or fusion zone is very thin and is discontinuous. It is black and opaque and whilst the outer margin is quite irregular the inner margin is regular forming a comparatively straight line with the second zone against it. The middle zone or absorption zone, (Saugzone) of Tschermak, is also comparatively narrow, though thicker than the outer zone, and consists of a fine aggregate of the silicate minerals, chiefly enstatite. The third or impregnation zone (Impregnation zone) of Tschermak, is almost entirely opaque but with irregularly disposed specks of the silicate minerals in it. This zone has an irregular but fairly constant margin between it and the absorption zone with a very irregular margin between it and the body of the aerolite, which causes the variations in thickness of the crust as a whole. The ratio between the thickness of the three zones at the point of maximum thickness is 1 : 3 : 9, where 1 is the fusion zone, 3 the absorption zone and 9 the impregnation zone.

In the absence of any chemical analysis the wirter proposes to classify this aerolite as White Chondrite according to Brezina's classification and it is accordingly placed in in the class :—Stone, No. 14. White Chondrite. (Cw), in the Collection of Meteorites in the Indian Museum.

Classification.

VI. The Jajh deh Kot Lalu Aerolite.

On the 2nd May 1926, a meteorite fell at the village of Jajh deh Kot Lalu (Lat. 26° 45′ N., long. 68° 25′ E.), in the Faizganj taluk of Khairpur State, Sind. Two fragments were sent to the Geological Survey of India for examination. This fall has been named after the village in which the fragments fell, its registered number being 291. The larger of the two fragments has been very kindly presented to the Indian Museum by the Khairpur Darbar: a portion of this is to be sent to the British Museum, while the remainder will be exhibited in the Meteorite Collection in the Museum, Calcutta. The smaller fragment has been returned and is, it is understood, being presented to the Karachi Museum.

Account of the fall.

The details of this fall are contained in the following letter dated May 24th 1926, from the Vazir, Khairpur State, to the Political Agent, Khairpur State.

"I have the honour to inform you that I have this day sent to your address by separate registered post a small case containing two pieces of thunderbolt, in the shape of black stones, that have fallen down from the sky near village Jajh deh Kot Lalu, taluka Faizganj on the 2nd instant between 5 and 6 p.m. The Mukhtyarkar of Faizganj reports that first of all a thunder sound continued for a little while in the sky and soon afterwards it was brought to his notice that a stone had fallen down. On witnessing the spot the Mukhtyarkar found that it had gone about six inches deep in the earth and was broken in two pieces." In response to a request for further information the following additional details of the fall were obtained. Both pieces of the meteorite were found in the same hole, and when recovered were neither hot nor cold to the touch. No light phenomena are said to have accompanied the fall. The direction of the fall was not noticed by the person who recovered the pieces as he was then fetching water from a well at a distance of about 750 feet from the spot.

General description of the aerolite.

The aerolite as received by the Geological Survey of India, consisted of two fragments, the larger weighing 753·05 grammes, the smaller 220·15 grammes.

The two pieces were recorded as having been recovered from the same hole, but attempts to fit the two fragments together have failed.

The larger piece is a fragment of a larger stone, all except two of the faces being fracture surfaces. The shape of this piece, as may be seen in Plate 11, fig. 1, is that of an irregular hexagon having a smooth crust covered surface seen to the front of the photograph, and a fairly flat fracture surface behind.

The front surface in Plate 11, fig. 1, and also the surface on the right-hand side, are comparatively smooth and have on them patches of what the writer regards as original crust. As is clearly seen in the photograph the crust on the larger surface is discontinuous and numerous patches are no longer crust-covered, these showing a paler colour in the photograph. A close examination with a lens reveals the fact that each of these crustless patches is connected with a certain amount of polishing and grooving, which gives a resemblance to a slickensided surface. The exact origin of these occurrences is obscure.

The original crust is dark grey to black in colour; it is somewhat scoriaceous, but shows no signs of flow structure, from which one might deduce the orientation of the fragments in flight. The crust is thin but quite clearly differentiated from the pale-coloured original material.

Two sides, a half front view of which is presented on the left of the piece in Plate 11, fig. 2, are almost covered with a secondary crust, which is dark grey in colour and quite thin; in fact it hardly amounts to more than a discolouration of the original material.

When first received in Calcutta the broken surfaces of the fragment showed a compact crystalline looking fracture of a steel grey colour. Even in the course of a week a considerable change took place due to the damp climate of Calcutta and the broken surfaces now have a rusty grey colour and have lost much of their original sparkle.

The surfaces are covered with innumerable metallic specks, the majority of which have the tin-white lustre of nickel-iron; but some have the bronzy lustre of troilite. The structure is not markedly chondritic.

The smaller fragment is also a portion of a larger stone, but as already stated, attempts to fit it to the other fragment have failed.

In shape the smaller piece is not unlike a sector of an orange. It has a smooth, curved outer surface, seen in Plate 11, fig. 1, which is covered with original crust. This crust is similar in appearance to that on the larger fragment, though it is lighter in colour. The other two surfaces, seen in Plate 11, fig. 2, are fracture surfaces, one of which, seen on the left in the photograph, is covered with secondary crust. A small surface at the top is also covered with secondary crust, whilst one at the bottom is not.

The secondary crust is probably black in colour, but it is very badly masked by adhering terrestrial material of a pale red and yellow colour. The crust is comparatively thin and finely scoriaceous.

Specific gravity.

The specific gravity of the pieces has been determined by hydrostatic weighing to be as follows :—

Larger piece	3·60
Smaller piece	3·62

Thin slices of this aerolite when microscopically examined show it to possess a very imperfectly developed chondritic structure. For the most part the aerolite consists of a confused granular aggregate, mainly enstatite with a moderate proportion of interstitial oligoclase (?). In addition to the silicate minerals there is a high proportion of nickel-iron and some troilite. The metallic minerals occur filling the interstices between the other minerals and are therefore irregularly shaped and haphazard as to disposition.

Microscopic characters.

Crossing one of the slides is a thread-like vein which is seen to be entirely filled with the metallic minerals.

There are a few cases of what appear to be chondri of enstatite, but the boundaries are very poorly defined and the chondri, if such they are, are mis-shapen and badly developed. For the most part the enstatite occurs in tabular particles, some of which are almost idiomorphic.

The writer has compared this meteorite with others in the Meteorite Collection in the Indian Museum and it bears the nearest outward relationship to the Kernouv fall. In the absence of any chemical analysis this meteorite is classified as Stone: No. 40, Veined Crystalline Chondrite, Çka of Brezina.

Classification.

LIST OF PLATES.

MGIPC—M—V-Z-18—1-6-27—800.

K. F. Watkinson, Photos *G. S. I. Calcutta.*

FIGS. 1 & 2. THE ADHI KOT METEORITE, ¾ *natural size*.

FIG. 1. THE ADHI KOT METEORITE, ¾ *natural size*.

K. F. Watkinson & G. V. Hobson, Photos. *G. S. I. Calcutta.*

FIG. 2. THE ATARRA METEORITE, ¾ *natural size*.

Fig. 1, *approximately ½ natural size.*

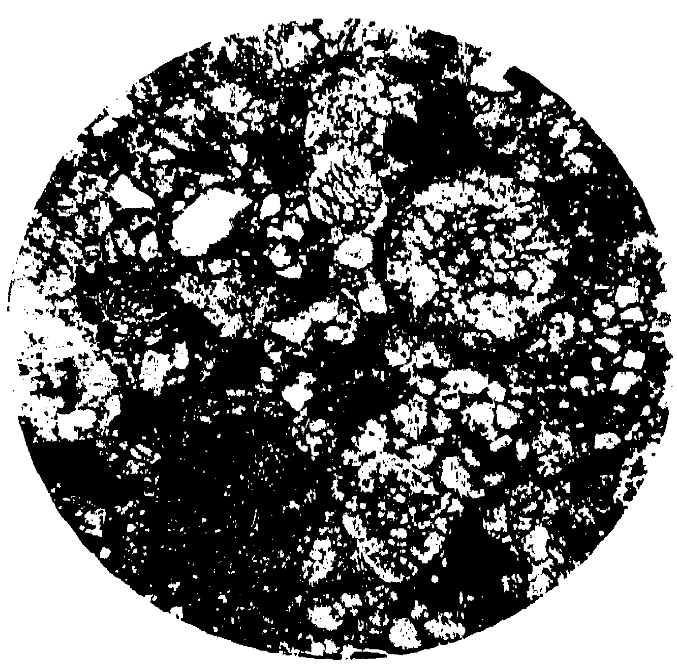


Fig. 2 × 15.

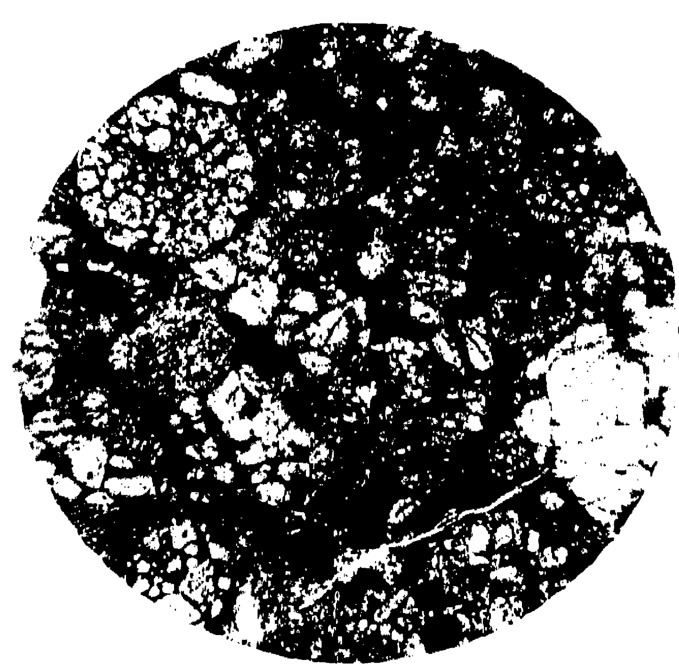


Fig. 3 × 15.

G. V. Hobson, Photos. *G. S. I. Calcutta.*

FIGS. 1, 2 & 3. THE ATARRA METEORITE.

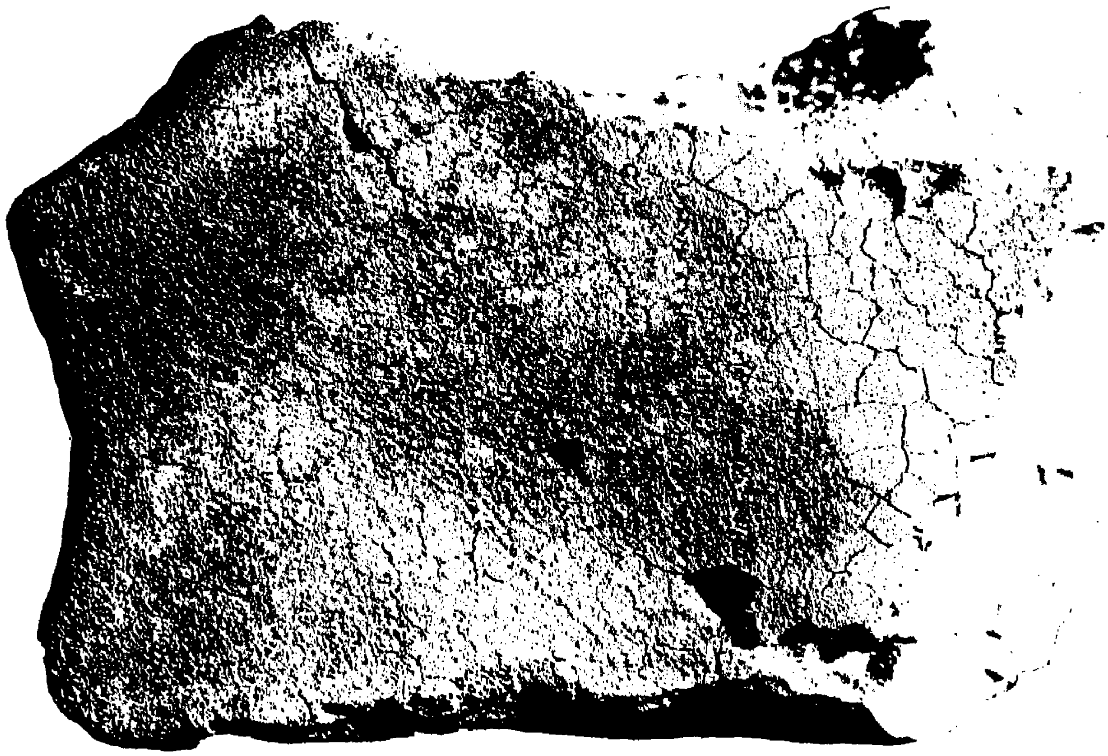


Fig. 1.

Fig. 2.

C. S. Fox & K. F. Watkinson, Photos. G. S. I. Calcutta.

FIGS. 1 & 2. THE HARIPURA METEORITE, *approx. nat. size.*

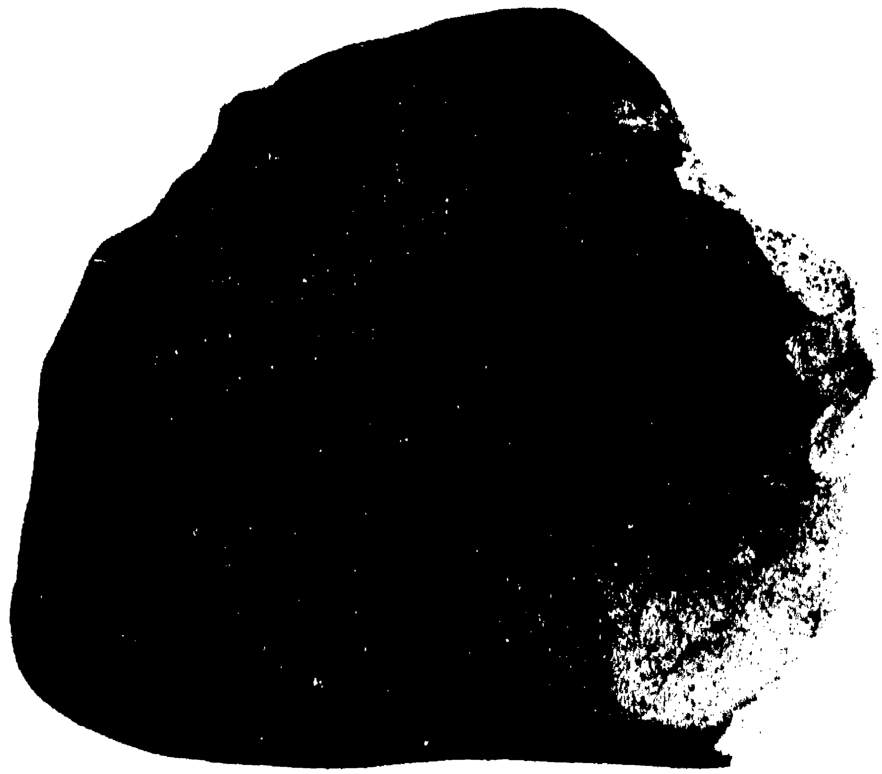


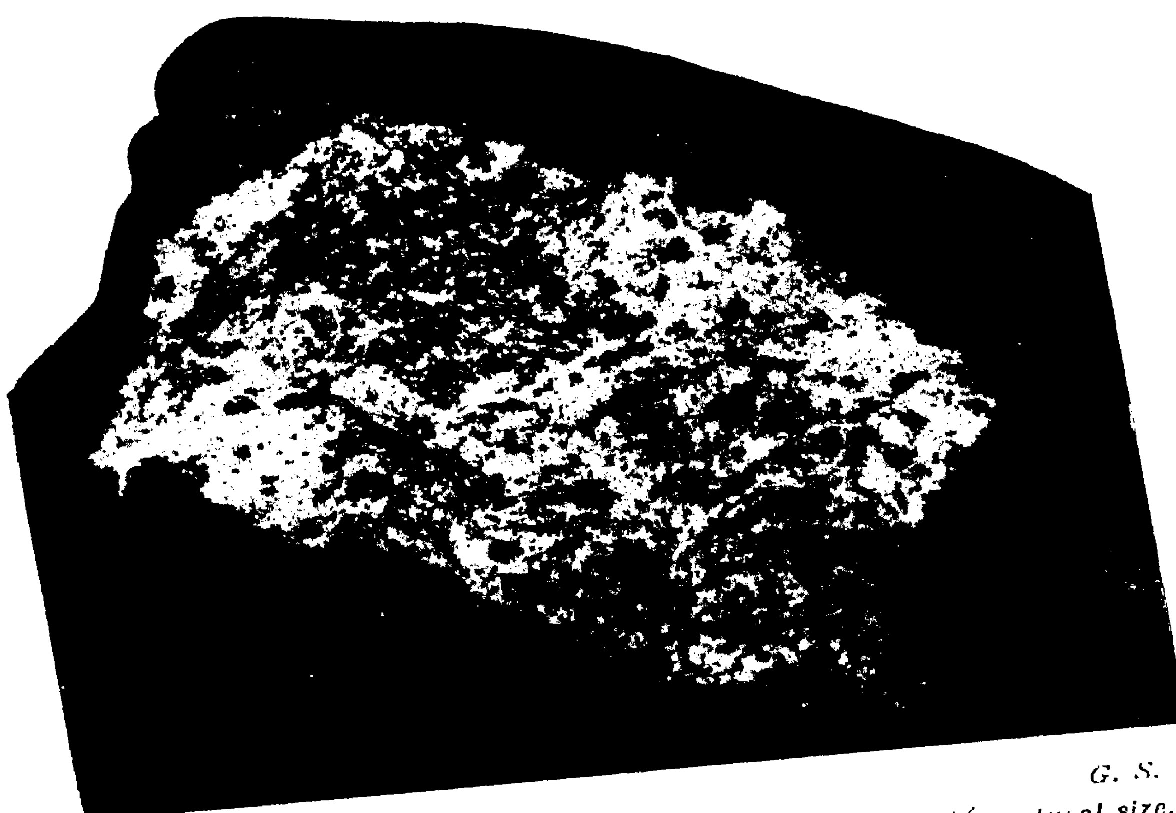
Fig. 1.

T. C. Chowdhury, Photos.

Fig. 2.

G. S. I. Calcutta.

FIGS. 1 & 2. THE SHIKARPUR METEORITE, 5/8 natural size.



G. S. I. Calcutta.

G. V. Hobson, Photos.

FIG. 1 & 2 THE SHIKARPUR METEORITE. Fig. 1 5/8 natural size.

Fig. 1.

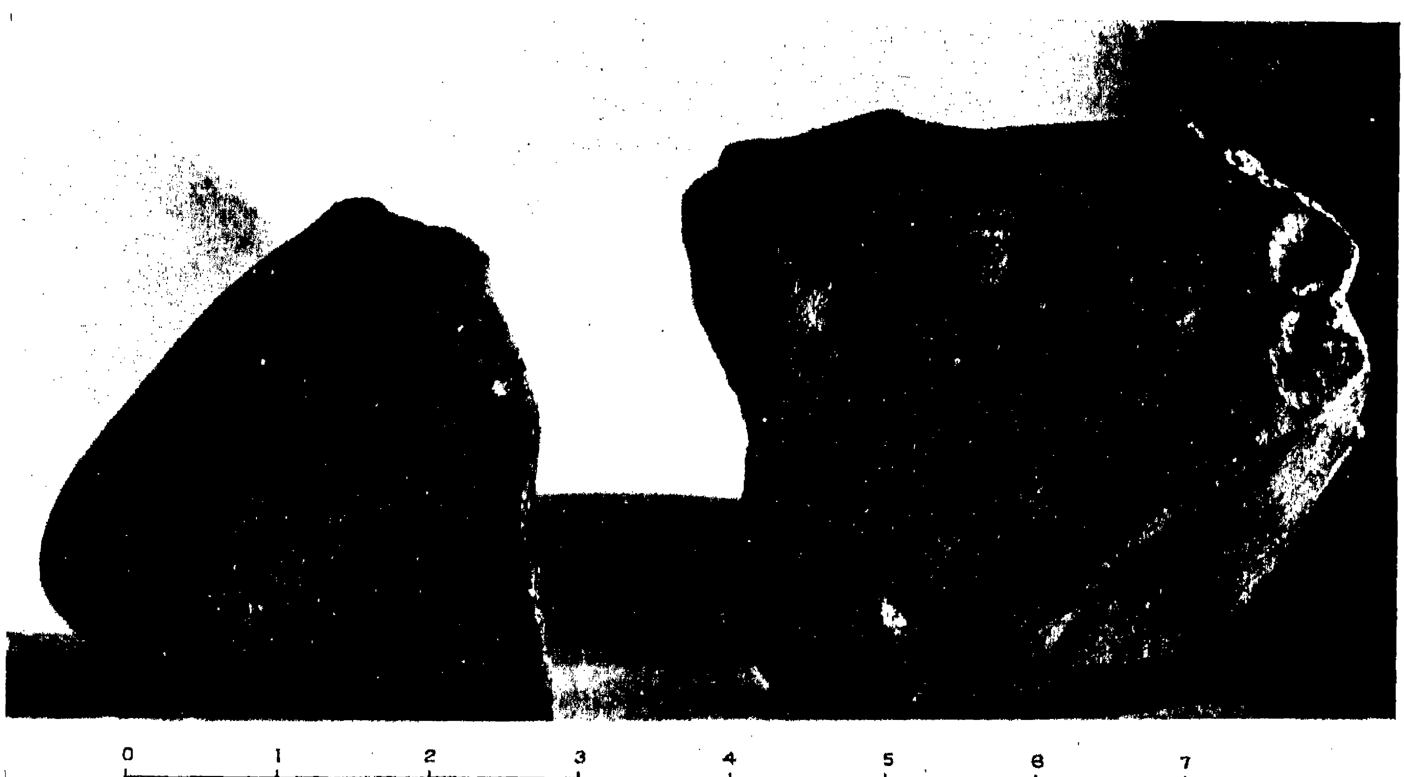


Fig. 2.

K. F. Watkinson, Photos. *G. S. I. Calcutta.*

FIGS. 1 & 2. THE MURAID METEORITE.

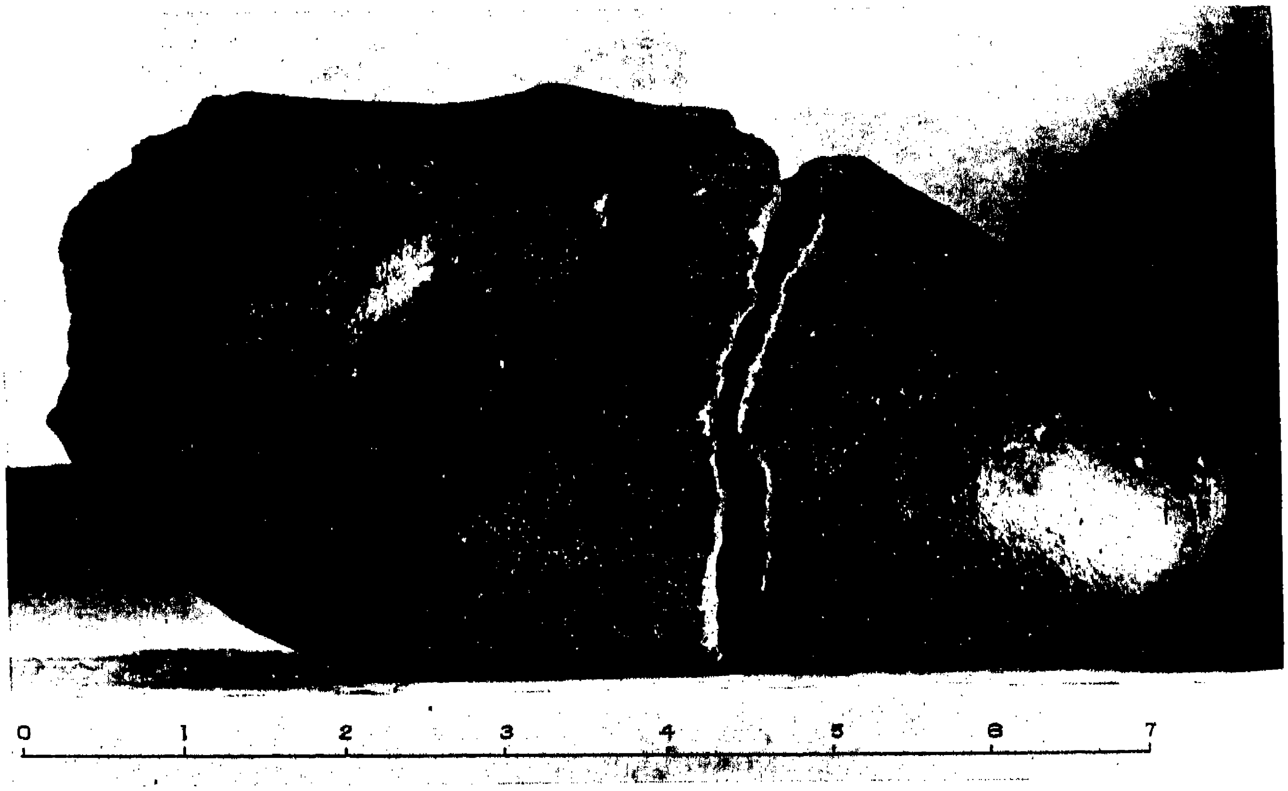


Fig. 1.

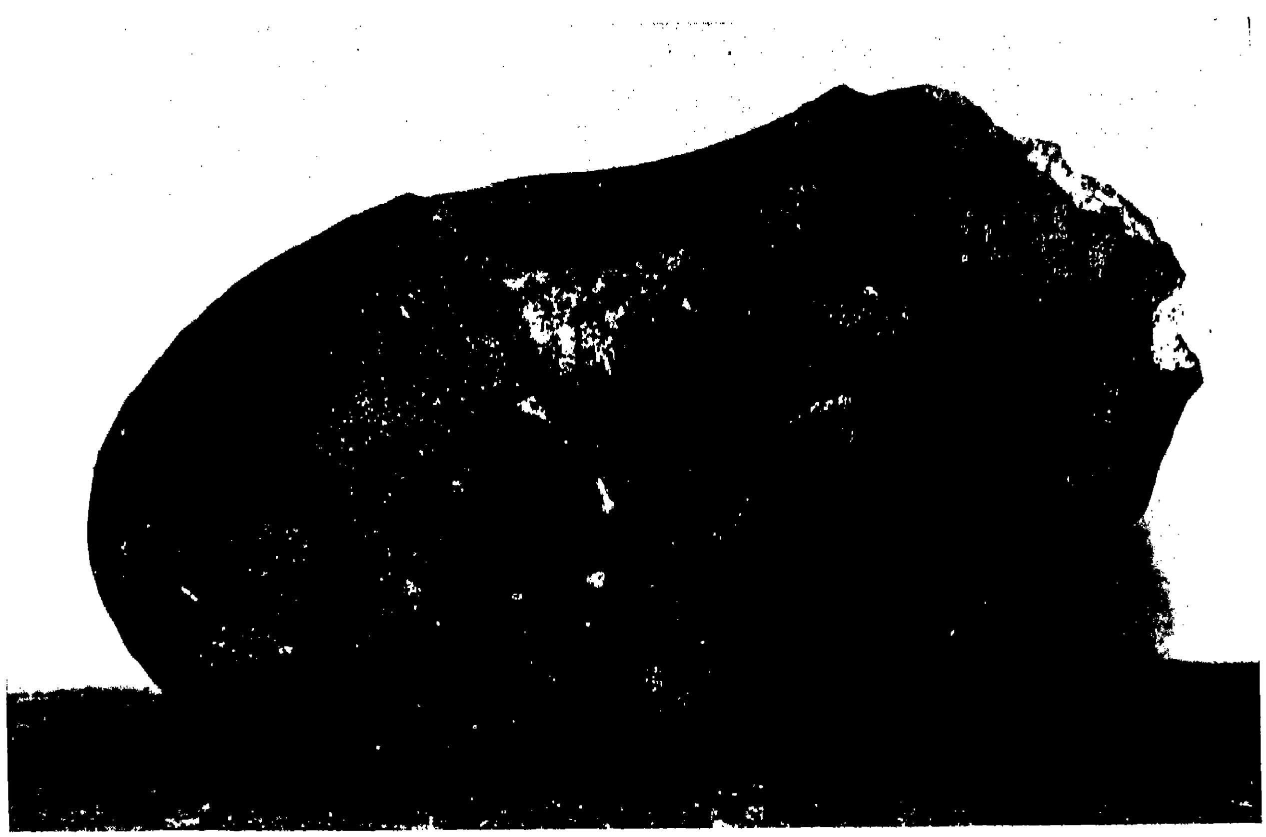


Fig. 2.

K. F. Watkinson & G. V. Hobson,, Photos. *G. S. I. Calcutta.*

FIGS. 1 & 2. THE MURAID METEORITE.

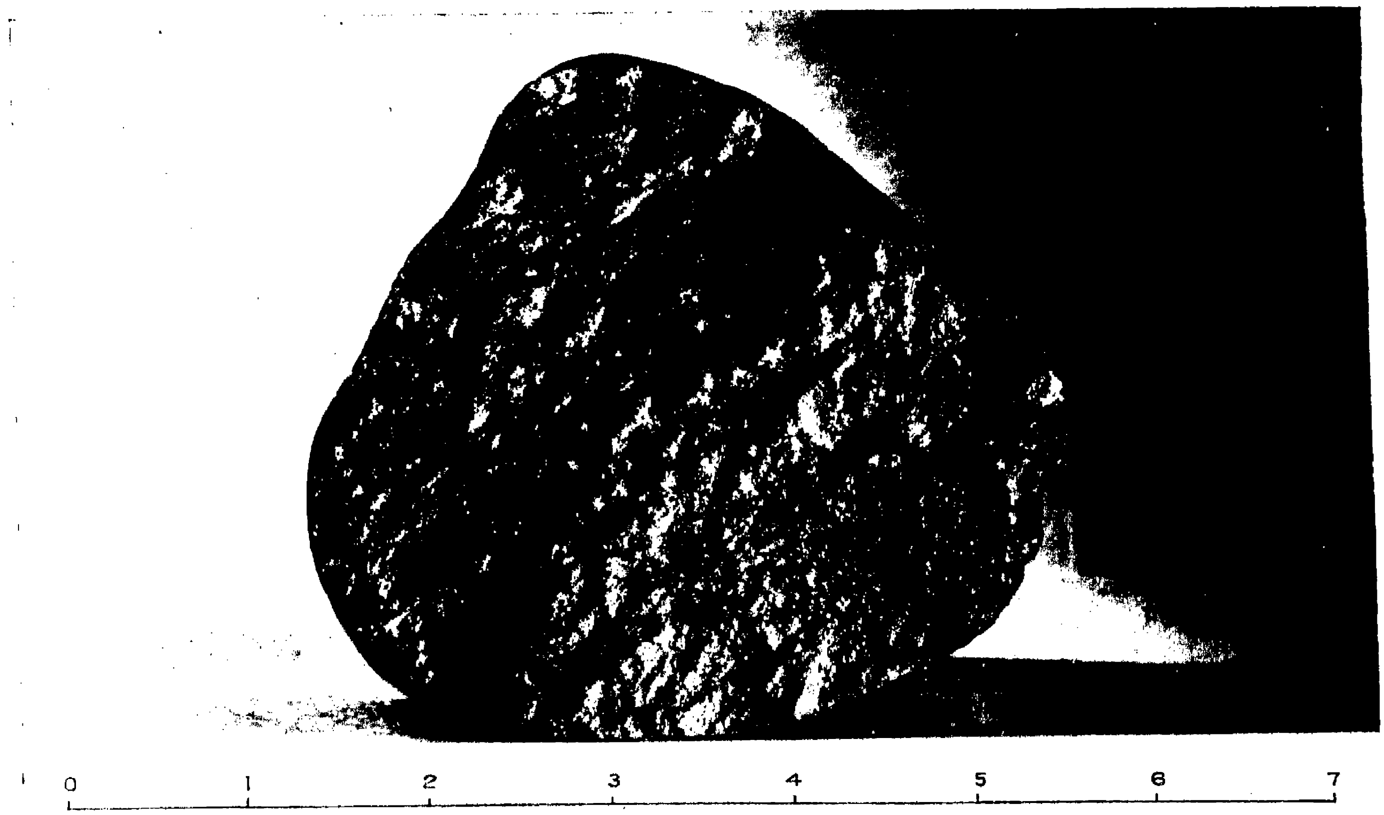


Fig. 1.

Fig. 2.

K. F. Watkinson, Photos. *G. S. I. Calcutta.*

FIGS. 1 & 2. THE MURAID METEORITE

K. F. Watkinson, Photos. *G. S. I. Calcutta.*

FIGS. 1 & 2. THE MURAID METEORITE.

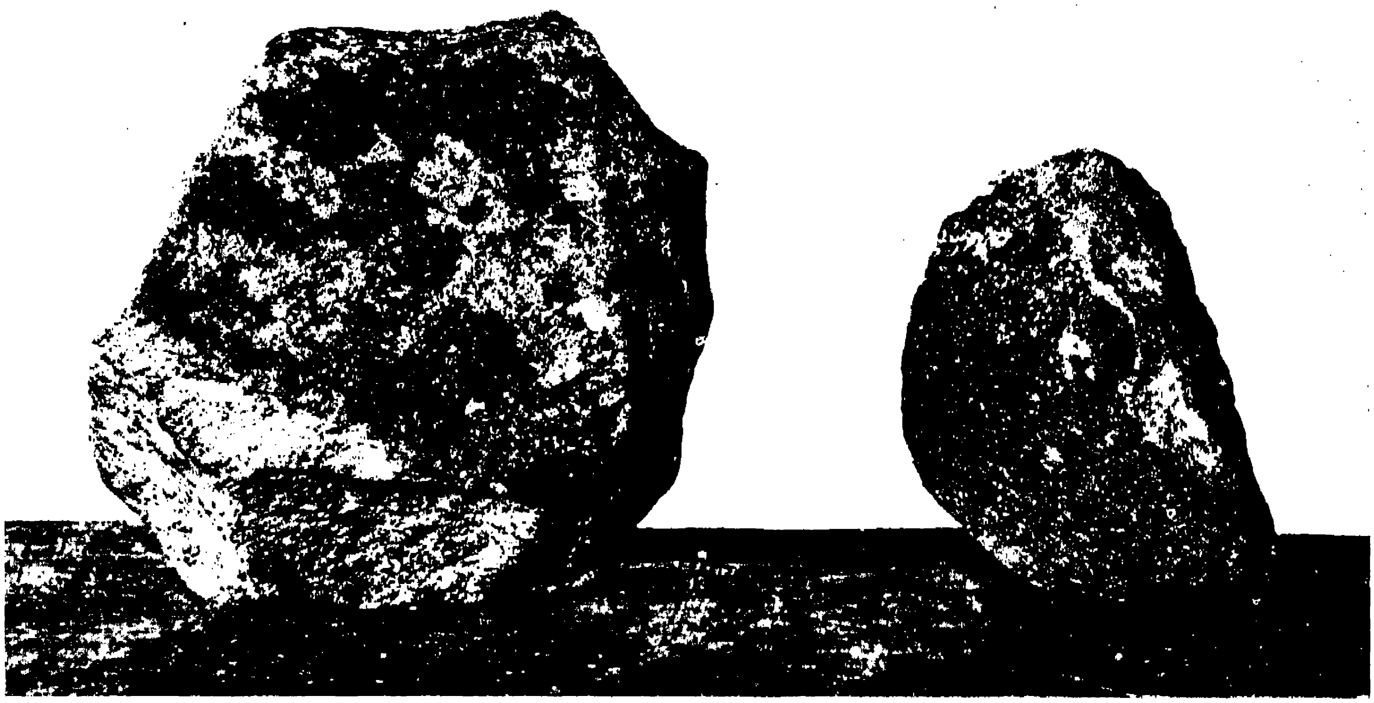


Fig. 1.

Fig. 2.

G. V. Hobson, Photos. *G. S. I. Calcutta.*

FIGS. 1. & 2. THE JAJH deh KOT LALU METEORITE, 2/3 *natural size.*

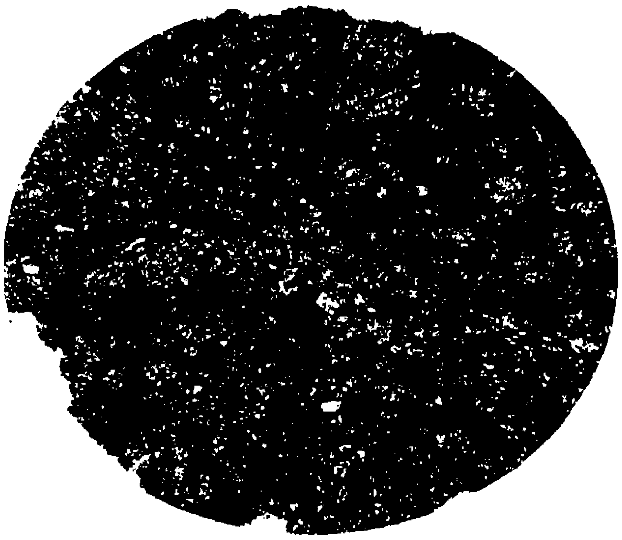


Fig. 1 × 15 *approx.*

Fig. 2 × 50 *approx.*

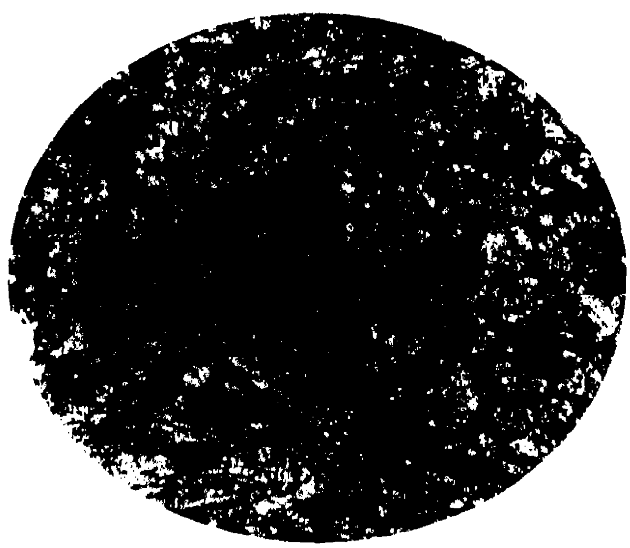


Fig. 3 × 20 *approx.*

Fig 4 × 10 *approx.*

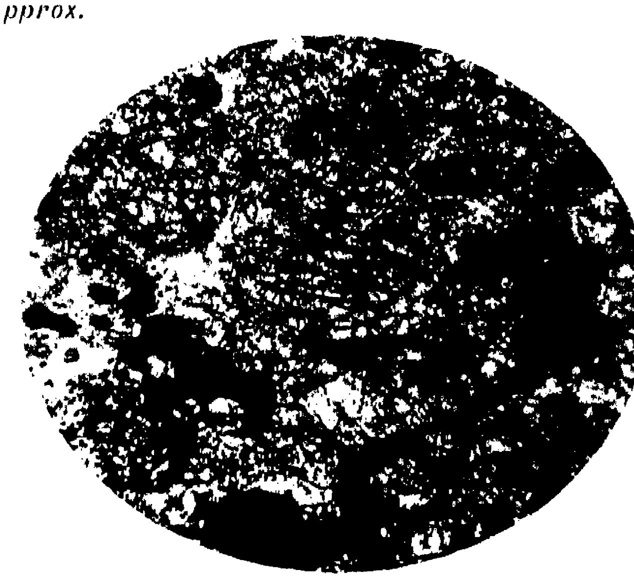


Fig. 5 × 15 *approx.*

G. V. Hobson, Photomicros. *G. S. I. Calcutta.*

FIGS. 1 & 2. THE MURAID METEORITE.
FIG. 3. THE JAJH deh KOT LALU METEORITE.
FIGS. 4 & 5. THE SHIKARPUR METEORITE.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2] 1927. [July

A Gas Eruption on Ramri Island, off the Arakan Coast of Burma, in July, 1926. By E. H. Pascoe, M.A., Sc.D. (Cantab.), D.Sc. (Lond.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

IT is well known that the east coast of the Bay of Bengal and the islands fringing it, from Chittagong to Cape Negraïs, have from time immemorial been subject to disturbances popularly regarded as of seismic or volcanic origin. This belt of disturbance can be traced by occasional submarine outbursts still further southwards past the Andaman and Nicobar Islands and beyond. Navigators are warned on the charts that newly-formed islands and dangerous shoals are to be expected in the neighbourhood. These outbursts have been lucidly reviewed by Dr. J. Coggin Brown (*Rec. Geol. Surv. Ind.*, Vol. LVI, pp. 250-256), and as it is highly desirable that as complete a list as possible of such occurrences should be made, the purpose of the present paper is to put on record an eruption which took place towards the end of July, 1926.

The importance of locating and recording eruptions of this kind lies in the fact that the safety of ships at sea is concerned, and that valuable information regarding the tectonics and rocks of the locality is sometimes derived therefrom.

Some of the disturbances experienced along various parts of the coast have exhibited some of the characteristics of true seismic phenomena; others, on the other hand, comparatively shallow in origin, are obviously the result of the accumulation and sudden

liberation of hydrocarbon gases. As the writer has pointed out more than once, gas and oil occurrences are frequently found along comparatively narrow belts which correspond to ancient marine gulfs subsequently silted up. It is interesting to trace the extension of such gulfs which are characteristic of Haug's geosynclinals fringing his continental areas. It is not always easy, especially in ancient accounts of by-gone disturbances, to distinguish between true earthquake phenomena and phenomena attributable to gas accumulation. In fact, it seems highly probable that the two have often occurred simultaneously. It is to be expected that the liberation of accumulated and concentrated gas might be prematurely brought about by an earthquake. We, should, therefore, rather expect to find a true earthquake in such areas accompanied by outbursts of gas and the pseudo-volcanic effects produced thereby. The converse, however, does not follow, and most of the eruptions in Ramri, Cheduba and elsewhere have been entirely unaccompanied by any truly volcanic or seismic characteristics; an "earthquake" is frequently reported in the immediate vicinity of the gas eruption, but this is a purely local result of the disturbance which has no far-reaching effect. It should be clearly understood, therefore, that the so-called "mud-volcanees" of Burma, although their formation and eruption may have coincided with true earthquakes, have nothing directly to do with the latter, or with volcanic phenomena.

The Chittagong earthquake of 1762 is said to have been felt in Calcutta and to the north, and at Dacca, the limits of its effect lying between 16° and 23° N. latitude and 87° and 94° E. longitude. If so, it must be looked upon as a true earthquake. Although the region affected is gas-bearing, there seems to be no definite evidence that the shock was accompanied by gas eruptions[1]. During the great Cutch earthquake of June 1819, which was felt over the greater part of India, smoke and flame are reported to have been seen issuing from the ground. "Fire, to a certain extent, was said to have issued from a bituminous hill from which alum is made, near Murr," and "near the town of Sinderu......a number of small cones, six or eight feet in height, burst up from the ground, and continued for many days to emit bubbles of air and mud from their summits" (*Trans. Bomb. Geogr. Soc.*, Vol. X, p. 152). Since the Eocene series, *i.e.*, the petroliferous series of N. W. India, occurs in Cutch, it seems

[1] *Journ. Asiat. Soc. Beng.*, XII, p. 1047.

more than likely that the fire, bubbles of "air" and mud cones were all disturbances due to hydrocarbon gas which frequently becomes ignited by a spark caused by the friction of stones hurled out of a vent. An excellent instance of the simultaneous occurrences of the two kinds of phenomena is the Bay of Bengal earthquake which commenced about 7·55 a.m on the 31st December, 1881. Simultaneous with the shock of this earthquake felt in Akyab was a dense outburst of smoke and "broad massive flames of fire" from one of the Cheduba volcanoes witnessed from a ship off the mouth of the Sandoway River (*Rec. Geol. Surv. Ind.*, XV, p. 141). The shock was felt in Calcutta, Madras, the Andamans and Nicobars and elsewhere.

An instance in which the gas eruption was probably the cause and the earthquake a local effect is the disturbance on the 27th February, 1881, when there was an eruption of a "volcano on Cheduba accompanied by flames and a trembling of the earth, lasting one and a half hours" (*Rec. Geol. Surv. Ind.*, XIV, p. 197).

The disturbance primarily responsible for the present note was an ordinary eruption of gas and was not initiated by any seismic shock. According to the "Statesman" of the 17th August, 1926, it was witnessed at "2 a.m. on the night of July 29th" by Captain Robinson of the "Chakdiña" from a position, latitude 18° 32′ N., longitude 93° 17′ E., and bearing N. 36° E. and was by later observations located in Ramri Island abreast of the entrance of the Cheduba Strait. There seems to have been some mistake as to the date, however, as local officers subsequently reported it as having occurred at 3 a.m. on the morning of the 28th July. The sight was described as magnificent, consisting of sheets of flame estimated to have reached 1,000 feet in height. The flames appeared "detached, as if caused by oil fumes and gases becoming ignited." We are indebted to Maung Tha Hla, Subdivisional Officer of Kyaukpyu and to Maung Kyaw Zan U, Township Officer of Ramri for the following details forwarded through the Deputy Commissioner of the Kyaukpyu district.

The position of the vent is described with no great precision, but seems to coincide with the low hills indicated on the new one-inch map (Survey sheet 85 $\frac{E}{12}$) within a mile north of the small village of Pinlena (19° 4′ 50″; 93° 39′ 50″). Pinlena lies upon the western shore of Ramri Island three-quarters-of-a-mile to the north of the mouth of the Yanbauk Chaung and some $9\frac{1}{2}$ miles almost due west

of the town of Ramri; it forms part of what is known as the Kin village tract. The vent is an old one, and a "mud volcano" is described as having occupied the site previous to the eruption. Probably there was more than one vent, for the Township Officer of Ramri states that there were three hillocks previous to the eruption. Warning of the outburst was given in the form of a sound described as like that of a mill or of a steamer, followed by a roaring like that of the sea, which was heard at a great distance. A mass of vapour then poured out and caught fire, the flames reaching a great height. These flames were perceived by the villagers of Ledaung and Ramri and are described as having been visible within a radius of 30 miles; this is probably too modest an estimate. Gravel and sand ejected with the gas were carried by the force of the explosion assisted by the wind as far as the Thabyegyun village tract some four miles distant to the north-east.

Five acres of cultivable land on the hills and about 45 acres of land adjoining them to the north, east and south, were upheaved to form a new hill variously estimated as being 300 or 500 feet in height, 1 or 3 miles long and $\frac{3}{4}$ to 1 mile across, visible from Ledaung police station. A small island was at the same time formed in the sea about 2 miles off the coast, but was expected to disappear very shortly beneath the waves. A small subsidiary vent became active simultaneously in one of the hillocks to the south of the newly-formed hill.

About 200 acres in all were affected by the mud and heat, but many of the young paddy plants therein have since revived and only about 8 acres have been seriously affected. The village folk of Pinlena were unable to remain in their village owing to the heat, and one old man died the following day as a result of exposure. The village, consisting of some 60 houses, was uninjured. The eruption is reported to have lasted for half an hour. On the 30th, some $2\frac{1}{2}$ days later, a mud "crater," about an acre in extent, was reported to occupy the top of the new hill, but the heat prevented close access.

A similar eruption is remembered to have taken place at this spot about 48 years ago.

OIL INDICATIONS AT DRIGH ROAD NEAR KARACHI. BY H. CROOKSHANK, B.A., B.A.I. (DUB.), *Assistant Superintendent, Geological Survey of India.* (With Plate 13.)

A strong smell resembling that of crude oil was noted in the limestone core of a boring sunk during 1924 in a search for drinking water at Drigh Road near Karachi. The smell was first noticed in the drillings from a depth of 720 feet and continued intermittently down to 815 feet. At this point it increased, and an oily scum was observed floating to the surface with the saline water from the boring. According to Mr. E. J. Dougherty, the Engineer in charge of the work, this oily scum proceeded from a brown sandstone pierced at 815 feet.

On my arrival in Karachi about a year later I found the core lying in the sun and wind; as a result of this it had partly fallen in pieces, and had entirely lost its smell. The oily scum was unfortunately not visible as the escape of water from the deeper parts of the bore-hole had been stopped. I collected a sample of the brown sandstone from a depth of 815 feet, and tested it for hydrocarbons in the Geological Survey laboratory, but was unable to find any trace of them.

The difference between Mr. Dougherty's evidence and my own is probably due to the fact that his observations were obtained from the fresh core while mine were made on the relics after a year's exposure. He is unlikely to have been mistaken about a smell so characteristic as that of crude oil, and his evidence in fact merely confirms what was already a possibility on general geological grounds. On the assumption that traces of oil were seen I have attempted to fix the stratigraphical horizon of its occurrence.

According to Blanford the Rocks near Drigh Road belong to the Gaj series (Miocene). This is built up of marine limestones and muds with a few thin sandy layers, and is everywhere underlain by several hundred feet of sandstone belonging to the upper Nari series. Lower still thousands of feet of marine limestones and muds of lower Nari and Kirthar age are found. It is clear from Blanford's description that the upper Nari horizon is the only important arenaceous one among the lower Tertiary rocks of this part of Sind.

Except for thin sandy layers at depths of 282, 470 and 815 feet, the boring passes through limestones and muds to a depth of 821 feet; thereafter it lies wholly in sandstone. None of the above-mentioned sandy layers is one-tenth of the thickness of the upper Nari sandstones seen in the Karachi neighbourhood, nor are they lithologically similar. It is therefore most probable that they are merely arenaceous strata in the Gaj series.

The sandstone at the bottom of the bore-hole is at least 52 feet in thickness, and may be much more. As it contains water at high pressure and in great quantities, it is probably a widespread formation and no mere sandy lenticle. But the only important lower Tertiary sandstone in other parts of Sind belongs to the upper Nari group. Consequently the lower part of the bore has probably pierced the upper Nari rocks. This conclusion is supported by the close resemblance between the sandstone from the boring and the upper Nari sandstone which crops out at Muggar Pir some 16 miles to the north-west. The points of similarity are the very fine grain of the rocks from both localities and the presence in them of lenticles of mud and coaly chips. Against this it must be admitted that the Drigh Road sandstone is not very like the upper Nari rocks of the Habb valley some 25 miles distant. However, some variation in shallow water sediments laid down so far apart is only to be expected. Judging from these observations, I think it most likely that the Gaj-Nari junction is 821 feet below the top of the bore-hole. If this be so Mr. Dougherty's petroliferous sandstone must occur about 6 feet from the base of the Gaj series.

Throughout the core numerous fossil foraminifera and lamellibranchs were noted. In the lower part these are unfortunately very fragmentary, and I have been unable to identify any which would assist in fixing exact horizons. For this reason I have relied entirely on the lithology of the rocks in determining the exact position in the stratigraphical scale of this reported oil occurrence.

The upper Nari and Gaj rocks were deposited in a shallow gulf of the sea under conditions similar to those which have given rise to oil in other areas.[1] Assuming that oil has actually been formed in these beds, its presence in commercial quantity would depend largely on whether suitable reservoirs exist for its storage and accumulation. I propose to show that there is one such reservoir but that the Drigh Road boring failed to tap it.

[1] E. H. Pascoe; *Mem. Geol. Surv. Ind.*, Vol. XL, pp. 251-253, 322-324, and 455-457.

The rocks around Karachi have been subjected to lateral compressions acting in north-westerly and east-north-easterly directions. By far the most important of these has been the north-westerly one, which has bent the rocks N. W. of Karachi into sharp folds. Its effect has gradually died out towards the S. E. but is still well marked about Drigh Road. The east-north-easterly compression has been on a much smaller scale, but it has disturbed the strata in Kelat and at Muggar Pir, where dome structures are well developed. At Drigh Road its main effect has been to cause the anticlinal Gaj rocks to pitch towards the E.N.E., but there is a corresponding though smaller pitch to the W.S.W. This is very gradual at first and can only be visibly detected by standing at a distance, but it probably becomes steeper where the rock disappears beneath the Karachi alluvium, for Blanford shows several steep westerly dips along this junction (see map Pl. 13). As the rocks exposed about Karachi harbour belong to the overlying Manchhar series, there is reason to believe that this westerly dip continues. The crest of the main anticline lies approximately along the ridge separating the Mandal stream from the Malir river. The exact point along this line where the pitch changes from E.N.E. to W.S.W. is not very definite, but is somewhere in the vicinity of hill "253." This point is therefore the top of a dome which dips gently in all directions.

The rocks near Drigh Road have been deposited in a shallow gulf of the sea in Miocene times. They consist of alternating beds of permeable sandstones and impervious limestones or muds; and they are crowded with organic remains. Finally they have been elevated into a gentle dome structure. All the conditions usually associated with an oilfield are therefore present. The boring at Drigh Road was driven into the rocks 1½ miles from the apex of the dome, and would have had indifferent prospects of finding oil in any quantity. The fact that a strong smell of oil was noticed near the base of the Gaj series suggests the possibility of oil in larger quantities near the crest of the dome. Taking into consideration the favourable transport conditions and the extreme value of an oil-field situated within 5 miles of Karachi, a carefully sited boring at the highest point of the dome near hill "253" would, in my opinion, be a justifiable speculation.

EXPLANATION OF PLATE.

PLATE 13.—Geological map of Karachi and neighbourhood; Scale 1 inch = 2 miles.

The Lower Canine of Tetraconodon. By Guy E. Pilgrim, D.Sc., F.G.S., F.A.S.B., *Superintendent, Geological Survey of India.* (With Plate 14.)

During last year Mr. A. E. Day of the Indo-Burma Petroleum Company collected from the base of the Irrawaddy series at Yenangyaung, Burma, a portion of the right mandibular ramus of a large Suoid animal, which undoubtedly belongs to the genus *Tetraconodon* and is almost certainly referable to the species *Tetraconodon minor* Pilgrim. Mr. Day has generously presented the specimen to the Geological Survey of India and it has been registered B. 771 in the Survey collection. It is figured in Plate 14, which accompanies the present paper. Up till now the lower dentition of the genus *Tetraconodon* in front of p_3 has been unknown, and since the new specimen contains m_1, $p_{2\text{-}4}$ and the roots of p_1 and the canine, its discovery adds considerably to our knowledge of the genus. The last two premolars differ in certain details from the corresponding teeth of the type of *Tetraconodon minor* (B. 677) but as will be seen from the tabulated measurements on page 163, these differences are trifling and may be regarded as individual, more especially as the original specimens were collected in the same locality and probably from the same beds at Yenangyaung. The size of p relatively to that of m_1 agrees very nearly with the British Museum specimen (M. 12691) mentioned by Pilgrim,[1] so that the premolar enlargement is considerably less than in *Tetraconodon mirabilis* figured by Lydekker,[2] and considerably greater than in any species of *Conohyus*. P_3 is slightly shorter than in the type and narrower in proportion; both anterior and posterior cusps are less prominent and thus resemble somewhat those of *T. mirabilis*, from which however the tooth is easily distinguished by its much greater slenderness. Similarly the posterior cusp of p_4 is less stoutly built than in the type of *T. minor*. I am not inclined to regard these differences as due to more than individual variation.

P_2 is a small, low-crowned tooth which does not exhibit any trace of the enlargement which the last two premolars have undergone; in fact if it be compared with the corresponding tooth of the

[1] *Pal. Ind.* (new series) Vol. VIII, Mem. 4, p. 17 (1926).
[2] *Pal. Ind.* (ser. 10) Vol. I, p. 79 (1879).

European *Conohyus simorrensis* described and figured by Hoffmann[1] under the name of *Hyotherium sommeringii,* it will be apparent that relatively to m_1 it has become rather reduced. The corresponding tooth in the Indian species of *Conohyus* is unknown. P_2 in the present specimen has strong anterior and posterior cusps. The anterior cusp is more in the nature of a prominent cingulum, since the median cusp is not high and on either side of it there are crenulations; this crenulated area almost joins an external crenulated cingulum, which is best marked between the main and the posterior cusps. The surface of the enamel as a whole displays the rugosity which is characteristic of the last two premolars. The presence of these prominent fore and aft talons distinguishes p_2 from the corresponding tooth in *Conohyus simorrensis.*

There is a diastema of 10 mm. between p_2 and p_1. The latter tooth is known only by the hinder portion of its root, but appears to have been quite as broad as p_2 and may not have been inferior to it in length.

The root of the canine extends within the body of the ramus as far as p_1, but its crown and the uppermost portion of the root have been broken away. A cross-section of the root is figured in Plate 14. It is seen that this is well on its way towards the scrofic type and is thus entirely different from the cross-section of the lower canine in *Sivachoerus giganteus*, which is markedly verrucose, and is also more scrofic than in the Middle and Lower Siwalik species of *Propotamochoerus* and *Dicoryphochoerus.*[2] On the assumption that *Tetraconodon* was directly derived from *Conohyus* which the writer[3], following Stehlin, adopted, it was to be expected *a priori* that the lower male canine in both genera would have a similar type of cross-section. The lower canine of the Indian species of *Conohyus* is unknown but that of the European *Conohyus simorrensis* is shown by Stehlin[4] to possess a much more pronounced scrofic cross-section. The writer holds Forsyth Major's view that the verrucose type of lower canine is the original one and that from it the scrofic type has been evolved.[5] It follows, therefore, that a species with a

[1] Die Fauna von Goriach, *Abh. k. k. geol. Reichs.* Vol. XV. pt. 6, p. 80, Pl. XVI, figs. 3, 4 (1893).

[2] Pilgrim, *op. cit.* Pl. XX, figs. 3-16.

[3] *Op. cit.* p. 15.

[4] Ueber die Geschichte des Suiden-Gebisses. *Abh. Schw. Pal. Gesells.* Vol. XXVII, Pl. 7 (1900).

[5] *Ann. Mag. Nat. Hist.* (6) Vol. XIX (1897), p. 523; Pilgrim, *op. cit.* pp. 4-6.

strongly scrofic type of lower canine could not have been the direct ancestor of another with a less scrofic canine, and one is therefore driven to the conclusion that either the Indian species of *Conohyus* were less progressive in this respect than their European contemporary or that *Tetraconodon* was derived from an older form than any known species of *Conohyus*. Perhaps the former is the more likely supposition; there is nothing against the idea that *Conohyus simorrensis* was a representative of a precocious branch, but proof of it must need await the discovery of the lower canine of the Indian species of that genus.

Since writing the memoir on the Fossil Suidae of India, I have become convinced that this change from a verrucose to a scrofic type of lower canine may have occurred with extraordinary rapidity in certain regions or on certain branches, and that therefore the separation between the lines of *Propalæochœrus*, *Dicoryphochœrus* and *Sus*, which after all is largely based on this difference between the lower canines, took place at a considerably later date than I have shown in the phylogenetic table published in the memoir quoted (Pl. I). The common ancestor to the three lines mentioned may even be found as late as the Lower Oligocene. The late acquisition of the scrofic canine in *Tetraconodon* supports this view in so far as it suggests that its precocious acquisition in the closely allied *Conohyus* must have been abrupt, at any rate in one part of the world, even if gradual elsewhere.

Geological Horizon.

The base of the Irrawaddy series, whence the specimen here described was obtained, even though it may mark a definite stratigraphical boundary, appears not to represent a constant chronological horizon.[1] Consequently its precise age in individual localities must be estimated from the character of the fossil fauna in each case. The age of the Yenangyaung beds has been discussed elsewhere.[2] The species hitherto found occur at different levels, ranging from the base to some 4,500 feet above it; it is, therefore, possible that the upper levels may belong to the Tatrot horizon (Upper Siwalik). At the same time since no Nagri species has been recognized at Yenangyoung, it would be an unwarranted assumption to put the age of *Tetracono-*

[1] Cotter, The geotectonics of the Tertiary Irrawaddy basin. *Jour. As. Soc. Beng.* N. S. Vol. XIV, 1918, p. 417; Pilgrim, The Tertiary formations of India. *Proc. Pan-Pacific Congress* 1923, p. 923; General Report, Geological Survey of India. *Rec. Geol. Surv. Ind.* Vol. LIX, 1927.

[2] Pilgrim, *Rec. Geol. Surv. Ind.* Vol. XL (1910), pp. 196-197; Pilgrim, *op. cit.* p. 922.

don minor as early as the Nagri horizon. Since the majority of the fossils found belong to typical Dhok Pathan (Pontian) species, it will be better to accept that as the age of *Tetraconodon minor.*

Measurements of Tetraconodon and Conohyus.

—		Tetraconodon minor (B. 771).	Tetraconodon minor type ramus (B. 677).	Tetraconodon mirabilis type ramus (B. 71).	Conohyus simorrensis from Labitschberg, figured by Hoffmann Pl. XVI figs. 1-4.
P_2	Ant. post. diam. . .	19·8	..	..	14·8
	Trans. diam. . . .	10·7	..	..	5·6
P_3	Ant. post. diam. . .	37·1	38·7	56·1	16·2
	Trans. diam. . . .	27·0	25·8	49·2	7·2
P_4	Ant. post. diam. . . .	34·6	34·8	53·4	17·0
	Trans. diam. . . .	31·1	31·5	56·4	9·2
M_1	Ant. post. diam. . .	24·0	..	31·1	16·8
	Trans. diam. . .	20·4	..	28·7	12·8

EXPLANATION OF PLATE.

PLATE 14, Fig. 1.—*Tetraconodon minor* Pilg. Right mandibular ramus with m_1, p_{2-4} and roots of p_1 and canine, surface view, natural size. From the base of the Irrawaddy series at Yenangyaung, Burma (B. 771).

Fig. 2.—Cross section through the root of the canine in the same specimen. Natural size.

THE GEOLOGY OF BUNDI STATE, RAJPUTANA. BY A. L. COULSON, M.SC. (MELB.), D.I.C. (LOND.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 15 to 22.)

I. INTRODUCTION.

Bundi State.

Bundi State lies between 26° 0′ and 25° 0′ north latitude and 76° 22′ and 75° 18′ east longitude. Its area is 2,218 square miles and it is roughly 85 miles long by 50 miles broad.

Physiography.

The state is traversed throughout its whole length from south-west to north-east by a range of hills; in the south-west this is single and crowned by a plateau, but near Satur it splits into two ridges which run in parallel lines to the north-east. Throughout the length of the range, there are only two passes. The more important of these is at Bundi, where there are fair roads both to Nasirabad and to Kotah; the other, which is only passable by pack bullocks, and that with difficulty, is at Khatkar. The latter pass has been cut out by the Mej River (see Plate 15, fig. 1).

The highest elevation of the ridge is 1,793 feet above sea level, near Satur. Near Bundi the average height is 1,400 feet or some 600 feet above the level of the plain. The range of hills effectively divides the country into two drainage basins, the northern being drained by the Mej River and its tributary the Bajain, the southern by the Mej and its tributary the Kural. The Mej joins the Chambal, which is the boundary between Kotah and Bundi States.

Area embraced in this paper.

In this paper it is proposed to consider in detail only the Vindhyan System, rocks of which form the main ridge and crop out over the area to the south of the ridge, with only a brief description of the Gwaliors in order to understand better the relations between these and the Vindhyans. The mapping was done on the scale of 1 inch =1 mile, and the area surveyed includes portions of sheets (old

numbers) 234, 265, 266 and 294, Central India and Rajputana Topographical Survey. The author commenced field work in the latter part of field season 1923-24 and, jointly with Mr. E. J. Bradshaw, completed the survey during season 1924-25. Mr. B. C. Gupta, Sub-Assistant, assisted in 1923-24 and the first part of the season 1924-25. The paper embodies the joint conclusions of Mr. Bradshaw and the author.

The latitudes and longitudes of all villages and height stations mentioned in the text will be found in the locality index appended to the paper.

II. PREVIOUS WORKERS.

Hacket and Kishen Singh.

The area was geologically mapped by Messrs. C. A. Hacket and Kishen Singh in 1881 and the results are embodied in Hacket's Progress Report for that season and also in the Records.[1] In sheets 265 and 294, there are practically no boundaries in accordance with Hacket's in the northern part of the Vindhyans. The positions of the various faults have been altered and after studying the rocks in the field, it has been concluded that the older maps were drawn from traverses across the ranges.

Datunda trap.

Hacket mentions trap as occurring at Datunda. Here he has mistaken a dark limestone for basalt. The only trap in this neighbourhood is at Khenia, in Gwalior rocks of which boundaries were drawn by Mr. B. C. Gupta while working with Dr. A. M. Heron at Khenia.

Datunda quartzite.

With reference to the quartzite near Datunda, Hacket states in his Progress Report that "they may possibly be Vindhyans, but more probably they are outliers of Alwar quartzites of the Mandalgarh hills which also occur near the line of the fault."

Bundi-Lakheri ridge.

He took the southern ridge of quartzite, extending from the Mira Sab ka Dongar at Bundi to Lakheri to be Kaimur in age as "there is far too great a thickness both of the shales and sandstone for it to be Lower Rewahs, but the Lower Rewahs may exist in the covered ground between the two ridges."

[1] *Rec., Geol. Surv. Ind.*, XIV, pt. 4 (1881), pp. 279-303.

It will be seen, also, that most of Hacket's Kaimurs in the northern parts of sheets 265 and 294 have now been correlated with the Lower Bhander sandstone.

A. M. Heron.

Dr. A. M. Heron has geologically mapped the Vindhyan regions to the north and north-east of the Bundi area and is at present continuing that work to the south-west in Mewar. In his published map of south-eastern Rajputana[1] he shows the rocks forming the hills near Lakheri and Balwan as undivided Vindhyans. These have now been subdivided.

III. LITHOLOGICAL DESCRIPTION OF ROCKS.

A. Gwalior system		
B. Upper Vindhyan system		
	Upper Kaimur	1. Kaimur sandstone and conglomerate .
	Lower Rewah	2. Panna and Jhiri shales and Lower Rewah sandstone . . . . . .
	Upper Rewah	3. Upper Rewah sandstone . . .
	Lower Bhander	4. Ganurgarh shales . . . . .
		5. Lower Bhander limestone . . .
		6. Samria shales . . . . .
		7. Lower Bhander sandstone . . .
		8. Sirbu shales . . . . .
	Upper Bhander	9. Upper Bhander sandstone . . .
		10. Upper Bhander limestone. . . .
		11. Upper Bhander shales . . .
C. Recent and Sub-Recent Deposits		

A.—GWALIOR SYSTEM.

Aravallis or Gwaliors.

The oldest rocks of the area are more allied to the Gwalior type of Dr. Heron in the area which lies to the north-east of Bundi, than to the Aravalli type of Ajmer-Merwara to the north-west.[2] It is quite possible that the line of separation between the two types follows some such direction as the line joining Pagara in Bundi and Loari in Mewar, because near Pagara well-defined conglomerates and breccias have been found (16405,[3] 34/414[4]; 34/420; 34/421; 34/422; 16408, 34/426),

[1] *Mem., Geol. Surv. Ind.*, XLV., Pl. 40.
[2] Heron: *Mem., Geol. Surv. Ind.*, XLV, pt. 2, pp. 133-45.
[3] Number of microscope slide in the Geological Survey of India register.
[4] Number of rock specimen in the Geological Survey of India register.

Consequently, the rocks situated to the south-east of this line are here referred to the Gwaliors rather than to the Aravallis ; but this attribution must not be taken as certain. These rocks will be more fully described by Mr. Bradshaw in an account of the adjoining portion of Mewar.

Rock types.

The Gwaliors of the area comprise phyllites, shales, slates, greywacke, limestones, sandstones and quartzites. The general strike is approximately N.E.-S.W., and the dip north-west, varying in amount. The intrusive rocks are mainly pegmatites with white reef-quartz, subordinate pink felspar and muscovite; they are presumably the same as the "newer" pegmatites of the Ajmer-Merwara area to the north-west, *i.e.*, post-Delhi in age. Trap has been recorded near Khodi in the north (16410, 34/434) and there is a large mass near Khenia (16096-98) —an olivine dolerite.

The usual shale is of a ferruginous nature (34/418 ; 33/500, 15695 ; 33/502, 15696 ; 15699) ; it possesses a strong reddish colour and glistening surfaces. Phyllites have abundant mica (34/416 ; 34/417) and at times show well-twinned crystals of staurolite (34/415). The limestones are usually more crystallised than the Vindhyan varieties and some of them approach marbles (34/412). In this connection the Umar limestones or marbles have been extensively used as a local building stone.

Dhaneum Conglomerate.

A very definite conglomerate has been recorded from Dhaneum in the Gwaliors. Specimens of this (34/468) show large rounded pebbles of reef-quartz, chert and shale, the whole being greatly silicified (Plate 17, fig 2). This bed has not been noted elsewhere ; it is considered to denote a local change of conditions of deposition in the Gwaliors in this region. It is possibly a part of the Ranthambhor quartzites (see p. 172).

B.—UPPER VINDHYANS.

1. *Kaimur Conglomerate and Sandstone.*

Kaimur group.

The Kaimur group is in many respects the most interesting of the Upper Vindhyan series. It is the basal group of the series and generally consists of a strong sandstone resting upon a conglomerate which, in its turn, rests upon the Gwaliors. In Mallet's areas [1] the conglomerate is

[1] *Mem., Geol. Surv. Ind.*, VII, pt.1 (1871), pp. 49-62.

only some six or eight feet thick as a maximum, whilst the Upper Kaimur sandstone varies from a few feet to more than 300 feet. Forming his Lower Kaimur, as distinct from the Upper Kaimurs just mentioned, Mallet has the Lower Kaimur sandstone and the Bijaigarh shales. In the description of the Upper Vindhyans to the north-east of this area, Heron's lowest member of the Upper Vindhyans is the Kaimur conglomerate, which rests unconformably upon the Lower Vindhyans. The succession near Chitorgarh in Mewar is as follows[1] :—

Kaimur sandstone.
Suket shales.
Nimbahera limestone.
Nimbahera shales.
Boulder bed and conglomerate.
Unconformity.

The beds beneath the Kaimur sandstone are said to be perfectly conformable with it.

Akoda Kaimurs.

In the Vindhyan range in Bundi the Kaimurs are found only to the north of the hills and stretch for some 32 miles, with sundry breaks, from Akoda Height Station to Antarda and then reappear in the extreme north-east of the area at Mohanpura. The largest expanse is at Akoda Height Station where the conglomerate and sandstone unconformably overlie the folded Gwalior beds. The top of the plateau has a slight general dip to the north-north-west.

Conglomerate.

The Kaimur conglomerate varies in thickness up to about 8 feet, but is a constant member. In the hand specimen (34.466; see also Plate 17, fig. 1) one notices small pebbles of white reef-quartz, red and black jasper, fragments of shale, sandstone and felspar, white and black chert, etc.[2] As Mallet states,[3] the bulk of the pebbles far exceeds that of the matrix. The pebbles show up better on a weathered than on a fresh surface.

Sandstone.

The Kaimur sandstone is the only sandstone of the Bundi Upper Vindhyans with a fairly constant colour. It is always definitely red and this colour, in conjunction with the presence of the conglomerate, was taken as

[1] Personal communication from Dr. A. M. Heron.
[2] See also Heron, *op. cit.*, pp. 152-3.
[3] Mallet, *op. cit.*, pp. 55-6.

sufficient to denote the Kaimur age of the rock. In general, the rock is fine-grained and well jointed.

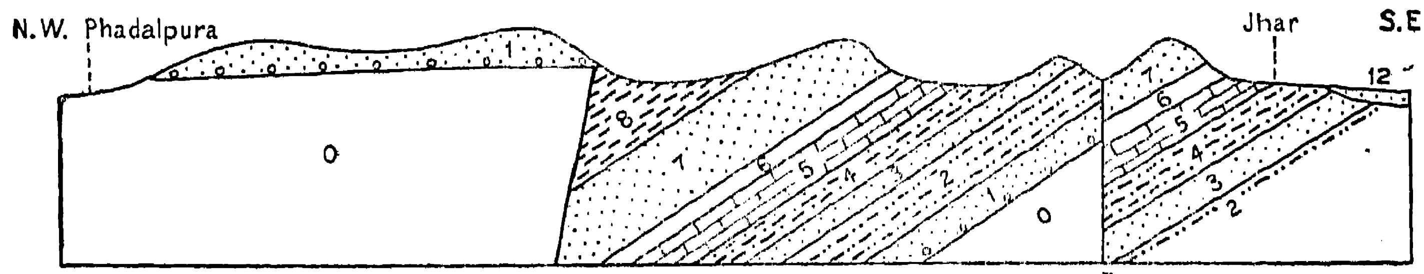
Thickness.

In no case were the Panna shales found overlying the Kaimur sandstone and so it was impossible to estimate accurately the thickness of the group. Were it not for the known sequence in other Vindhyan areas, it would have been impossible to identify the Panna shales as the beds immediately overlying the Kaimurs. The general thickness of the Kaimur sandstone seen was about 100 to 120 feet.

Map alterations.

It will be noticed that slight alterations have been made to the rocks mapped as Gwaliors in the south-west corner of Heron's map of South-Eastern Rajputana, as definite Kaimur conglomerate and sandstone were found here. The chief difference between the maps of Hacket and Kishen Singh and those attached to this paper is in the extent of the Kaimurs, which have been reduced to nearly one-third of their extent in the older maps. The ridge of quartzite extending from Bundi to Lakheri is undoubtedly Lower Bhander ; it is conformably underlain by Samria shales, Lower Bhander limestone and Ganurgarh shales (*see* fig. 1) and no trace of conglomerate could be found in spite of diligent search. Hacket's Kaimurs to the north of his boundary fault were found to consist of a variety of rock types and great alterations have been made in the mapping.

Heron considers that the rocks underlying the Kaimur conglomerate in the Akoda plateau and in the ridges parallel with the



12. Alluvium.
8. Sirbu shales.
7. Lower Bhander sandstone.
6. Samria shales.
5. Lower Bhander limestone.
4. Ganurgarh shales.
3. Upper Rewah sandstone.
2. Jhiri and Panna shales.
1. Kaimur sandstone and conglomerate.
0. Gwaliors.

F = Fault.

FIG. 1.—Sketch Section showing the relations of the Lower Bhander Sandstone of the Bundi-Lakheri Ridge.

fault and to the north of it, towards Antarda, may be in part representatives of the Ranthambhor quartzites, which are largely developed to the north-east in Jaipur,[1] and to the south-west, near Mandalgarh in Mewar, on the same strike.

2. *Panna and Jhiri Shales and Lower Rewah Sandstone.*

Lower Rewah group.

Mallet's Lower Rewah group is locally best considered as a whole as some at least of its members are very impersistent. In the type area Mallet[2] gives the thickness as varying from 590 feet to nothing. Heron gives the maximum thicknesses of the Panna shales, Lower Rewah sandstone and the Jhiri shales as 150, 250 and 500-600 feet respectively, figures considerably greater than those of Mallet.

Panna shales.

The Panna shales are a persistent if somewhat thin bed in Bundi. They are exposed in the valley between the Lower Bhander ridge of Mira Sab ka Dongar and the Upper Rewah ridge to the north. In the south-west, near Bundi, good sections may be seen. The shales (34/464) are usually well cleaved and also possess a strong cross-jointing. In colour, they have the usual variations from red to green and yellow. No limestone bands were recognized in definite Panna shales.

Lower Rewah sandstone.

The Lower Rewah sandstone is well exposed near Bundi and a few good sections of it occur in the valleys east of Loharpura (25° 28′; 75° 40′). To the north the sandstone appears to die out, but it is again developed near Kotri and Indargarh where it forms a ridge of mappable size. Here it is a light-coloured flaggy sandstone or quartzite, usually dipping at a low angle to the west, though it forms good anticlines and synclines in the immediate neighbourhood of Indargarh.

Jhiri shales.

The Jhiri shales form the thickest member of the Lower Rewah group, their maximum thickness being at least 100 feet. In cases where the Lower Rewah sandstone is not developed, it is a matter of impossibility to delimit the Jhiri from the Panna shales. An extremely good section of Jhiri shales, immediately underlying the Upper Rewah sandstone, is to be seen two miles north-east of Bundi. The shales are also developed in force at the foot of the scarp above Bundi;

[1] *Mem. Geol. Surv. Ind.*, XLV, pt. 2, pp. 133-8.
[2] *Op. cit.*, pp. 62-71. Heron, *op. cit.*, pp. 160-5.

here they are typically ferruginous, well-cleaved and jointed shales with no limestone bands.

Towards Indargarh limestone bands appear in the upper parts of the Jhiri shales, as well as in the Upper Rewah sandstone. The Motipura-Borupurio occurrence is very interesting. Here the Jhiri shales crop out on one side of an anticline of Upper Rewah sandstone and limestone which is faulted on its southern side against the Lower Bhander lime stone. A section showing the nature of the occurrence is given below (Fig. 2).

Limestone in Jhiri shales.

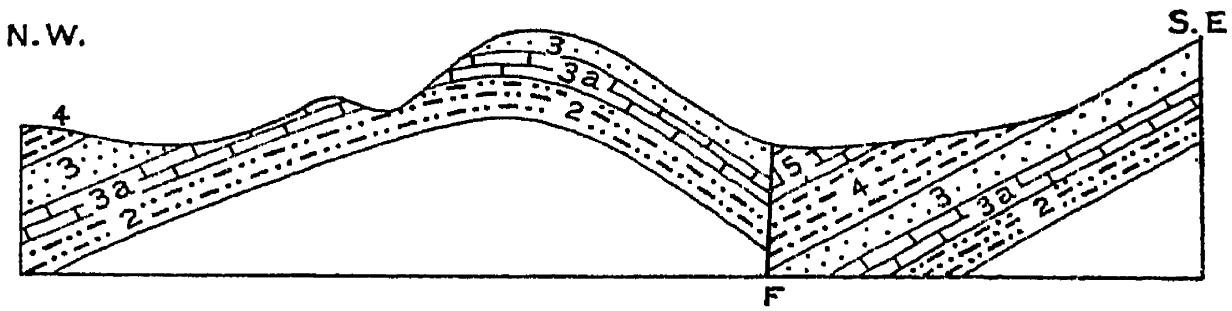


FIG. 2.—Section near Motipura. For explanation, *see* Fig. 1.
$3a$=Upper Rewah limestone.

All three members of the Lower Rewahs are developed at the foot of the scarp of Lower Bhanders near Arjipura (*q. v.*)

Arjipura.

3. *Upper Rewah Sandstone.*

The Upper Rewah sandstone—or quartzite, as here it certainly is—the upper member of the Rewah division of the Upper Vindhyans, varies enormously in thickness in Mallet's type areas [1] from 500 feet to 6,000 feet; in the Dhar forest they are supposed to attain the wonderful thickness of 10,000 feet, though the beds are probably not all Upper Rewahs.

Type Area.

In Bundi the Upper Rewah sandstone varies very greatly in extent and thickness. It is not found to the south-west of Bundi as the denudation of the country has not proceeded sufficiently far to expose it. North of Bundi the Upper Rewahs form the large mass upon which is built the fort which dominates the city. The dip of the strata is to the north-north-west at about 10° to 15°. The base of the series is very conglomeratic and sections (16412, 16413) show quartz and small felspars in a fine-grained matrix, which itself is siliceous. This is best shown at Suraj Chatri above Bundi,

Thickness, etc.

[1] *Op. cit.*, pp. 77, 78.

where there is a fine joint and fault scarp. The urface to the north is a good dip slope. The usual colour of the Upper Rewahs is yellow and their maximum thickness is about 300 feet.

This fort mass of Upper Rewah sandstone is perfectly continuous with that forming the range of hills running north-east from Shikarburaj in the valley between Tikarde and Bundi (*see* fig. 3). The dip increases to 25° or 30° north-north-west and the sandstone or quartzite becomes less hard and also slightly calcareous (16,430, 34/462). The calcareous nature increases as one goes north-east until, in the neighbourhood of Bhaironpura, Kotri and Motipura, as shown elsewhere, definite limestones appear in the group. The sandstone here has become much softer and is far from being the hardest quartzite of the Upper Vindhyans.[1] It is the softest of the sandstones, being at times quite friable; nevertheless, it forms a fairly prominent landmark as it crops out between the softer Ganurgarh shales to the north and Jhiri shales to the south.

Iron Ores at the junction with the Jhiris.

At the junction of the Jhiri shales and Upper Rewah sandstone, there are usually some ferruginous ochres and occasionally kaolin (pp. 191, 192). From Sheria to Chatarpura the folding of the Upper Rewahs is relatively intense and the beds are highly disturbed.

The Upper Rewah sandstone, being frequently flaggy and micaceous, is used locally for building purposes.

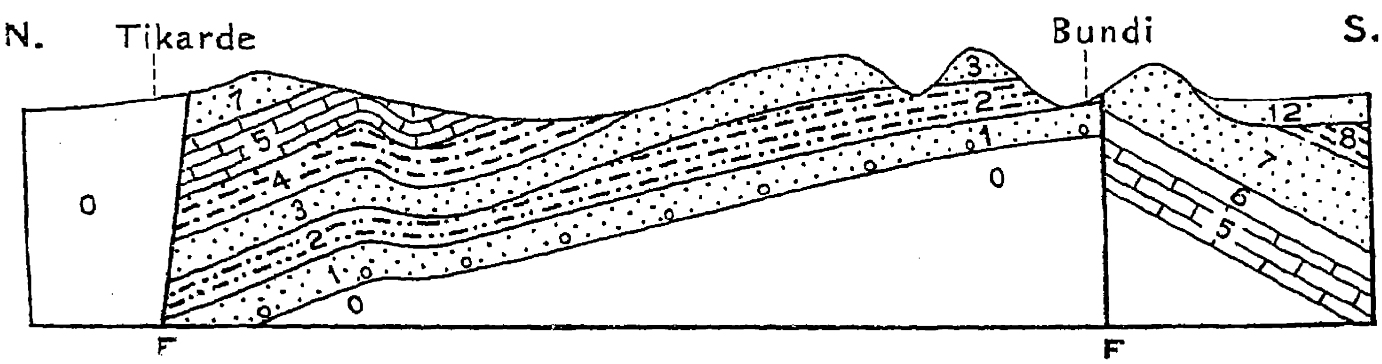


FIG. 3.—Section from Tikarde to Bundi. For explanation, *see* Fig. 1.

4. *Ganurgarh Shales.*

The Ganurgarh shales, the lowest division of Mallet's Lower Bhander group,[2] are some 400 feet thick in their type locality.

Thickness.

In Bundi they are a very constant member of the series and their thickness, though very variable, is generally in the neighbourhood of 600 feet.

[1] Heron, *op. cit.*, p. 165.
[2] *Op. cit.*, pp. 81-86.

Lithology.

The dominant types are shales which are usually more ferruginous than the shales of other divisions ; this is shown in the field by a deeper red colour than usual in both the shales and the overlying soil. Intercalated with the shales are thin-bedded limestones, pinkish in colour and fairly hard, and sandstones and quartzites. There is usually a cross-jointed slaty cleavage.

Good sections of the Ganurgarhs are to be seen at Loharpura, Manak Chok, and along the southern side of the ridge stretching from Gendoli to Lakheri. With reference to this ridge it is interesting to note that there is a strip of Ganurgarhs shown south of Jhar. This strip probably connects with the Gendoli-Lakheri outcrops though the shales are masked by alluvium. The dip has flattened considerably to the north-east at Lakheri and the width of outcrop is greatly increased. Quartzite bands are very common in the shales and, in the Lakheri area, they are sometimes quite thick.

The boundaries of the Ganurgarhs in the Satur anticline (*see* fig 4) are more or less approximate as exposures are poor ; also, the Ganurgarhs grade up into the Lower Bhander limestone. The mapping relies mainly upon the greater redness of the soil derived from the shales.

5. Lower Bhander Limestone.

Importance of the division.

The Lower Bhander limestone is the most important zoning division of the Bundi Upper Vindhyans and, without it, it would be almost impossible to make out any sequence of the rocks that would have a reasonable amount of certainty. Indeed, one may state that the sequence resulting from the study of these rocks, were it not for the known position of the Lower Bhander limestone from the study of the contiguous areas of Tonk and Karauli to the north-east by Dr. A. M. Heron [1] and to the south-west in Mewar by C. A. Hacket, would be different from that now generally accepted.

Characteristics.

The Lower Bhander limestone has certain characteristic features which render it easily recognizable. Apart from a few bands of limestone in the Jhiri shales, Upper Rewah sandstone and Ganurgarh shales, the only other limestone of any extent is the Upper Bhander limestone in the north-east of the area. This, of course, excepts the Gwalior limestones which by their occurrence cannot be mistaken for the Lower

[1] *Op. cit.*

Bhander limestone. The Upper Bhander limestone, however, rests directly upon a very strong sandstone, the Upper Bhander sandstone, whereas the Lower Bhander limestone rests upon the distinctive Ganurgarh shales. So there is no danger of confusing the two main limestones of the Upper Vindhyans. All the sandstones are more or less similar in appearance and so the recognition of a strong limestone with a definite position in the upper Vindhyan system is of great assistance in the true interpretation of the sequence.

Thickness.

The usual thickness of the Lower Bhander limestone in Mallet's areas [1] varies from about 100 to 250 feet. In Bundi the general thickness is of the nature of about 200-300 feet. The biggest outcrops are to be found in the Satur anticline (*see* fig. 4), west of Satur Height Station and to the south-east of Khenia. The northern limb of the anticline stretches north-east for some 33 miles in an unbroken strip, while the southern limb runs in the same direction for 6 miles.

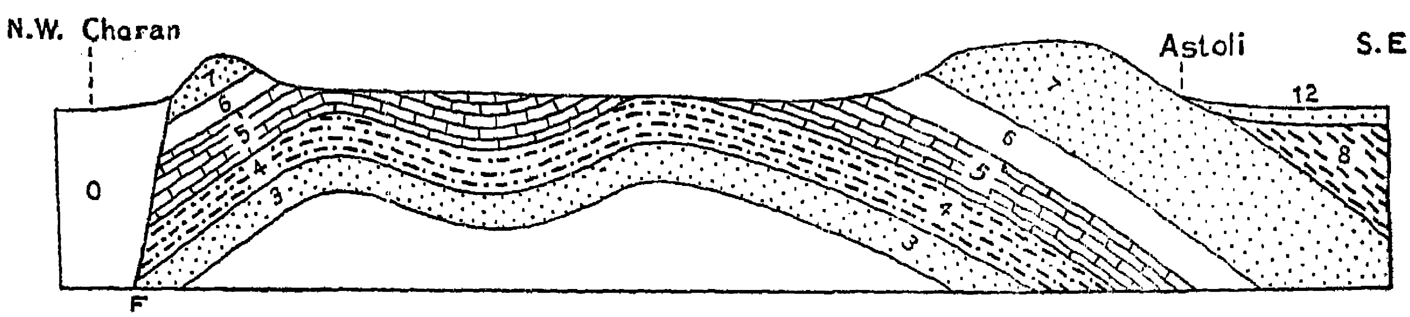


FIG. 4.—Section across the Satur anticline from Choran to Astoli. For explanation, *see* Fig. 1.

A great band of limestone runs from the foot of the Mira Sab ka Dongar at Bundi to Lakheri, some 37 miles; this is the limestone worked by the Bundi Portland Cement Company at Lakheri. The great Satur anticline has been worked sporadically for lime in the past.

There is much puckering and folding in the limestone near Satur and Dalelpur and it is impossible to obtain the true thickness of the bed here. Where the rock crops out normally, overlying the Ganurgarh shales and underlying the Samria shales, it is possible to estimate the thickness with some degree of accuracy.

Lithologically the Lower Bhander limestone is characteristically a thin-bedded rock, usually grey-blue, blue, pink or purple in

[1] *Op. cit.*, pp. 86-90.

colour ; grey-blue is the predominant colour. There is very little crystallisation in the rock and so it differs from the partially recrystallised marble limestones of the Gwaliors.

Microscopic sections (16411, 16420, 16427 and 16428) show the limestone to be composed of a fine-grained mass of calcite with quartz and, at times, varying amounts of iron oxide. In the two last sections, also, there are anastomosing veins of calcite which are slightly coarser in grain than the groundmass and are obviously secondary. No traces of fossil remains have been noted in the sections and hand specimens, though there are, at times, curious markings which are presumably of concretionary origin (*see* 16416 and 34/469 ; also Plate 18). These markings are of peculiar design and to some extent resemble the graphic structure of eutectic mixtures in pegmatite ; their origin, of course, is totally distinct.

Mode of origin of limestone.

The general appearance of the rocks under the microscope and also in the hand specimens suggests that they were deposited from calcareous solutions under marine conditions. No discinoid markings similar to those obtained by Mr. H. C. Jones from the Vindhyans near Neemuch were observed.[1]

Analysis.

In the economic section of this paper (*see* pp. 193, 194), the results of many analyses carried out by Mr. A. Weighell, Chemist to the Bundi Portland Cement Works at Lakheri, are given. Analyses of two samples, one from the lime quarry and the other from the cement quarry are given below and serve to indicate the composition of the stone :—

	Lime Quarry.	Cement Quarry.
SiO_2 (calcined)	25·26	24·73
SiO_2	16·51	16·23
Al_2O_3	3·38	3·61
Fe_2O_3	0·92	1·26
CaO	43·59	42·85
MgO	0·64	1·08
CO_2	33·84	33·26
H_2O etc.	0·63	0·84
TOTAL	99·51	99·13
Calcimeter Figure	76·9	75·6
Ratio $\frac{SiO_2}{Al_2O_3}$	4·88	4·49

[1] *See* page 18 ; also *Rec. Geol. Surv. Ind.*, LX, pt. 1 (1927), p. 18.

These figures may be compared with the analysis of the Upper Bhander limestone given on page 182.

6. Samria Shales.

Nomenclature.

The Samria shales were named by Kishen Singh from their occurrence near Samria in Mewar, where they are horizontally bedded and crop out in great force. The name does not appear to have been applied outside of the Bundi and Mewar areas as the shales to which it refers are elsewhere absent. Kishen Singh used the term upon his field maps of 1881-82 in Bundi and of 1883-84 in Mewar. For the purposes of this paper, it is convenient to employ the name for the shales and limestone overlying the Lower Bhander limestone and underlying the Lower Bhander sandstone.

Outcrops.

The Samria shales are best developed at the foot of the Mira Sab ka Dongar and in the neighbourhood of Khatkar, Talwas (*see* fig. 5) and Lakheri. In the south-western part of the State they are entirely absent, the Lower Bhander limestone being directly overlain by the Lower Bhander sandstone. Travelling north-east, the shales are first seen in the anticlinal region south of Datunda; here they are gently dipping, very thinly bedded, greenish and reddish shales of a typical Vindhyan nature. They contain no limestone. The outcrop is cut off to the north by the great boundary fault south of Narenpur and their next occurrence is in the anticlinal area south of Satur.

The Samria shales apparently die out again to the north-east, south of Tikarde, but reappear near Dalelpur and continue thence for some 29 miles to the north-east as a definite formation. They expand into a wide spread near Pipla and again at Talwas, being eventually cut out by the Antarda-Talwas-Motipura fault (*q. v.*). They underlie the Lower Bhander sandstone of the ridge running from Talwas to Mohanpura for some 12 miles. From Mira Sab ka Dongar, where they are exposed in force, they do not reappear until between Jhar and Khatkar, as their outcrop is masked by hill debris from the sandstone. From Khatkar onwards they form the bulk of the slope of the hill, being some 100 feet thick.

The shales are not easily distinguished from other shales of the Upper Vindhyans but a very useful facies in the rock is a thin, dark, buff, hard limestone which occurs at the top of the shales. This limestone can be seen near Dalelpur and also at Satur; it is

of varying thickness, from 6 to 12 feet approximately. The shales differ from the Ganurgarhs in that they do not contain quartzitic bands.

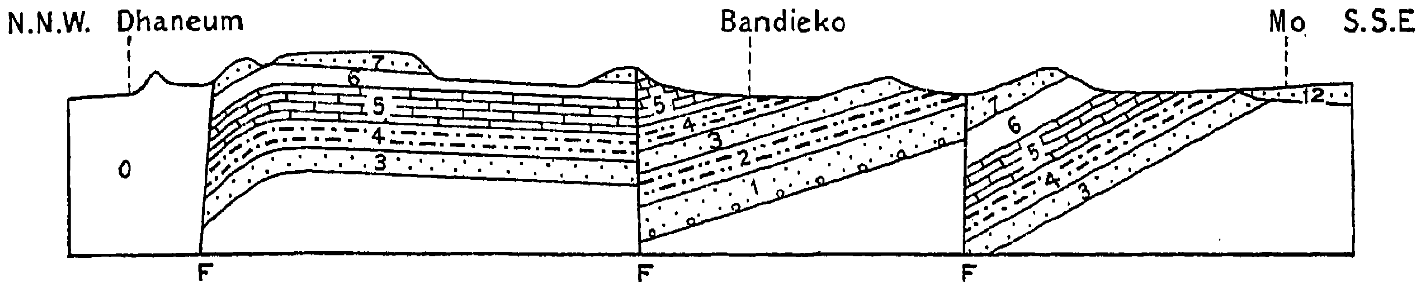


FIG. 5.—Section from Dhaneum to Mo, showing Samria Shales. For explanation, *see* Fig. 1.

7. *Lower Bhander Sandstone.*

Extent.

Whereas the Lower Bhander limestone is the most important zoning division in the Upper Vindhyans, the Lower Bhander sandstone is the most strongly developed member. In the Vindhyans to the north-east of Bundi it is the Upper Bhander sandstone which is the dominant sandstone, and this is generally true over the Central India and South-Eastern Rajputana occurrences.

In those portions of Bundi which are on Sheet 234 and the south-western part of 266, the Lower Bhander sandstone rolls with dips ranging from horizontality to 25°. Well-formed dip slopes abound, the whole being an undulating series of synclines and anticlines (see fig. 6). The Lower Bhander limestone crops out in the centre of the anticline near Khenia but otherwise the older beds are not exposed and the thickness cannot be estimated. The sandstone dips normally under the Sirbu shales of the plains to the south-west of Bundi city.

Thickness.

South of the Satur Height Station in the northern limb of the syncline, the strata are much disturbed and while the surface of the plateau is more or less horizontal, the southern limb dips at as great an angle as 70° to 80°, but it is generally about 30°. The total thickness from dips works out at about 2,600 feet. Near Height Station 1,373 feet, near Bundi, there has been much crumbling of the strata and a traverse through the hills along the stream-courses shows shales which are probably Samria shales; these, however, could not be mapped. This mass of sandstone is faulted with reference to the Mira Sab ka Dongar

mass, and it is probable that there are Sirbu shales in the valley where alluvium has been mapped.

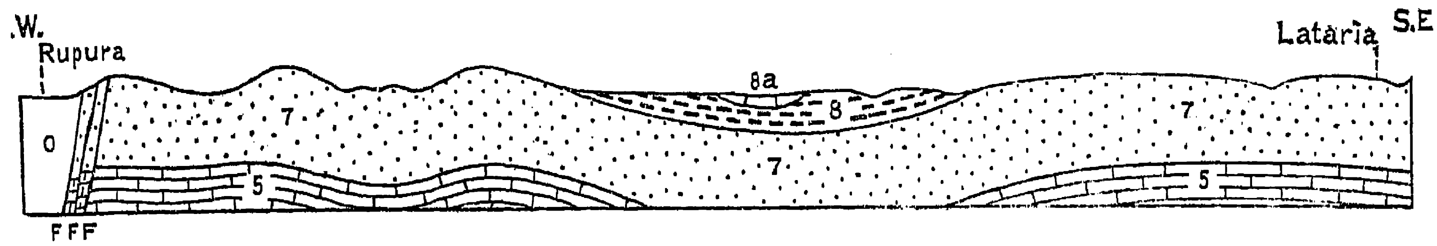


FIG. 6.—Section across the Vindhyans from Rupura to Lataria. For explanation, *see* Fig. 1. 8*a*=Limestone in Sirbu shales.

The sandstone of the northern limb of the Satur anticline is faulted out at Satur but reappears a mile to the south-east near Borkhandi and thence continues unbroken to Pipla.

There is a large continuous mass of Lower Bhander sandstone, about 1,000 feet thick, running from Mira Sab ka Dongar north-east. This is very impressive from the south where there is a pronounced joint or fault scarp (*see* Plate 15, fig. 2). The dip slope to the north has a constant dip of about 25° to 30° (*see* Plate 16, fig. 1).

In the north, the Lower Bhander sandstone crops out in great force, though its total thickness lessens to about 800 feet. Towards Mohanpura, it is faulted against the Gwaliors and, following south-west, the sandstone outcrops branch several times as, *e.g.*, at Antarda and Talwas, prominent dip slopes being formed; from Ramgarh to Bhaironpura (25° 31′ : 75° 43′), there is a large mass faulted against the Gwaliors to the north. The Lower Bhander sandstone here is strongly ripple-marked.

Petrology.

Petrologically, the sandstone varies greatly. The lower beds are usually fine-grained, red, and compact. Above this is a great thickness of white quartzite with a coarser, and usually hard, grit at the base (*see* Plate 16, fig. 2). When much compressed, this upper whitish quartzite very much resembles reef quartz, *e.g.*, at Datunda (16424, 34/472). There is commonly a little ferruginous cementing material in the rock and, on weathering, this is removed, giving the rock a vesicular appearance (16421).

Grit.

The grit varies in hardness and while south-west of Datunda it is very hard (16423) and contains a siliceous cement, east of Satur, as will be described later in the economic section, the grit is soft and crumbles to a powder on the application of very slight pressure, cementing material being absent.

Sandstone or quartzite.

For the purpose of unification the rock has been referred to as the Lower Bhander sandstone; as seen above, like the Kaimur and certain specimens of the Rewah, it would be more strictly called the Lower Bhander quartzite.

White and red types.

In the maps attached to this paper, no attempt has been made to demarcate the upper white and the lower red sandstones. In most places this was impossible ; in fact, the only regions where the differentiation could be made with certainty was adjoining the great boundary fault (*q.v.*) from Bhojgarh to Tikarde. This suggests that the upper whitish quartzite is really only a more metamorphosed form of the usual reddish variety. This point will be dealt with later under the structure of the area.

8. *Sirbu Shales.*

Extent and thickness.

In the Bundi area, the Sirbu shales are an important division as they crop out over a very large area. In the type area, as described by Mallet,[1] the Sirbus have a total thickness varying from 300 to 800 feet ; but in Bundi, their large outcrops are to be attributed more to horizontality of dip than to excessive thickness. Their general thickness is about 500 feet.

Limestone in Sirbu shales.

Though their widest spread is near Nim ka Khera they are not very well seen here except in the bed of the river as they are covered by alluvium. Towards the east, it is impossible to map the shales with any degree of certainty and so alluvium is shown. The shales near Nim ka Khera are reddish arenaceous shales with a conchoidal fracture, the dip being 2° north-west. Overlying these and taken as part of the Sirbus is a series of thinly bedded limestones which are different from the Lower Bhander limestones before described (*see* fig. 6). At times they are pure, but more commonly they are arenaceous and shaly.

These limestones are part and parcel of the Sirbu shales as they appear to dip under more shales. Near Thalera between Kotah and Bundi, limestones are exposed in the beds of the rivers and it is presumed that they are the same Sirbu limestones. Again, between

[1] *Op. cit.*, pp. 80-94.

Hatipura and Daolatpura there is a wide stretch of limestone exposed. This, in appearance, is not unlike the Lower Bhander limestone, but is rather more shaly. Well sections here were very indefinite and the limits of the limestone could not be defined with any great accuracy.

Sirbu shales probably occupy most of the area between the Lower Bhander sandstone south of Nim ka Kheta, and Lakheri. In the bed of the Mej River and its tributaries, stretching up to the Chambal River from Goar and along the Chambal to its junction with the Kali Sind River the shales are practically horizontal (*see* plate 19, fig. 1). To the north they underlie the Upper Bhander sandstone ridge, and to the west they are faulted with reference to the Ganurgarhs. The fault is lost in the alluvium to the south, but probably continues south-west, parallel to the big fault, which runs from Indargarh to Bundi between the Lower Bhander sandstone of the Bundi-Lakheri ridge and the Jhiri shales to the north.

The Sirbu shales near Sutario are very ferruginous and so resemble the Ganurgarhs, but they conformably overlie the Lower Bhander sandstone in the ridge to the south.

South of Mohanpura, the Sirbus occur in force, overlying the sandstone of the Indargarh ridge. They are faulted to the north against Gwalior shales, these showing much reef-quartz pegmatite.

Usually the Sirbus are very thinly cleaved with a good cross-jointing. Though ferruginous, they are not nearly so much so as the Ganurgarhs. All the Upper Vindhyan shales are somewhat similar and it is almost a matter of impossibility to name a shale outcrop when other stratigraphical evidence is wanting.

9. *Upper Bhander Sandstone.*

Extent and thickness.

Though this is the dominant sandstone of other Rajputana Vindhyan areas, in Bundi it is developed only in one ridge to the north-east of Lakheri. In the extreme north-eastern part of this ridge, the sandstone forms a succession of gently rolling anticlines and synclines. Following the ridge south-west, the folding is lost and the ridge simply dips towards the north-west at from 5° to 10°, the dip becoming more pronounced along the margins and forming a prominent dip slope. In the type areas the thickness of the Upper Bhander

sandstone[1] varies from 200 to 3,000 feet, but in Bundi the total thickness cannot be much more than 80 feet. Heron [2] obtained a section showing 1,600 feet.

In the south-western corner of the outcrop, the sandstone is much ripple-marked. It is generally a shallow-water deposit, like most of the sandstones. In colour it is less ferruginous than the Lower Bhander sandstone and, lithologically, is more a sandstone than a quartzite as it has not been subjected to as much stress and pressure as the other quartzitic members.

In the neighbourhood of Baklo the sandstone is well bedded and jointed and has been quarried for building purposes. As is well known, the Upper Bhander sandstone is perhaps the most important building-stone of Northern India.

The relations between the Sirbus to the south and the Upper Bhander sandstone (*see* fig. 7) are perfectly conformable as on the east side of the ridge the shales can be seen passing up into the sandstone.

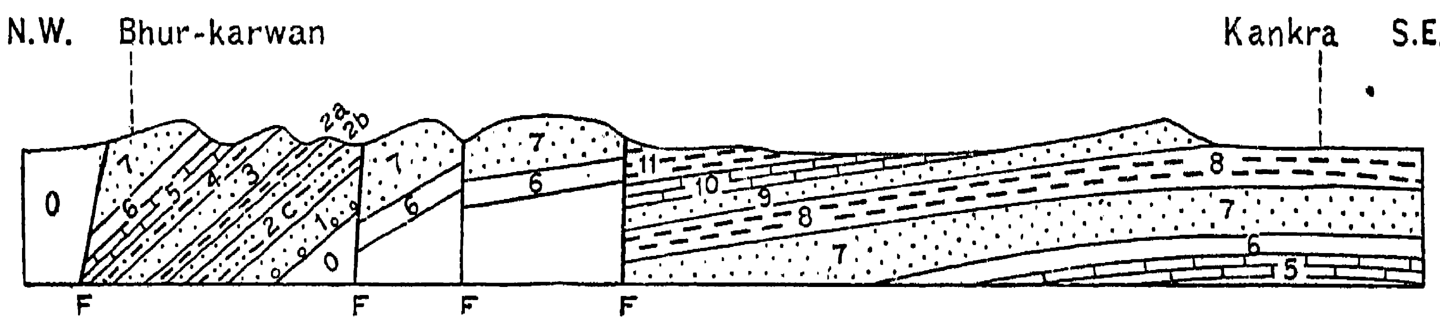


FIG. 7.—Section from Bhur-karwan to Kankra. For explanation, *see* Fig. 1.
11=Upper Bhander shales.
10=Upper Bhander limestone.
9=Upper Bhander sandstone.
2*a*=Jhiri shales.
2*b*=Lower Rewah sandstone.
2*c*=Panna shales.

10. *Upper Bhander Limestone.*

As far as can be discovered, there does not appear to have been a mention of this massive limestone in other Vindhyan areas. The Upper Bhander sandstone has been recognized generally as the highest member of the Upper

A new division.

[1] Mallet, *op. cit.*, p. 97.
[2] *Op. cit.*, p. 168.

Vindhyans, no other bed having been found resting upon it conformably.

A few miles to the east of Lakheri, resting perfectly conformably upon the Upper Bhander sandstone, which, in its turn, as has been described, rests conformably upon the Sirbu shales, is a massive limestone (*see* figs. 7 and 8). There is no possible doubt about the conformity of the relations, as good sections are to be seen along river courses. The limestone is distinct from the Lower Bhander limestone which is exposed a few miles away, across the railway line, where it is worked by the Bundi Portland Cement Company. This Lower Bhander limestone rests upon the Ganurgarh shales and is overlain by strong Samria shales and the Lower Bhander sandstone. The Upper Bhander limestone, whilst resting upon a sandstone, underlies a strong series of shales which have not been met with elsewhere. It was considered that the names "Upper Bhander limestone" and "Upper Bhander shales" were more desirable than local names such as "Balwan limestone" and "Kuarpura shales" which are not self-explanatory.

Characteristics.

Petrologically, the Upper Bhander limestone (16429, 34/461) consists of a very fine-grained mass of calcite with a secondary growth of larger calcite crystals. There is a moderate amount of ferruginous matter as an impurity. The hand specimen shows a very strong conchoidal fracture, whereas the Lower Bhander limestone is usually fissile. At times, also, this limestone shows concretionary markings.

Thickness.

The rock dips to the north-west at a very gentle angle, varying from 3° to 10°. The thickness from dips is 180 to 200 feet. The rock can be easily worked as there is practically no overburden.

Analysis.

An analysis of a sample, from 2½ miles east of Lakheri, undertaken in the Laboratory of the Geological Survey of India, gave the following results:—

SiO_2	6·68
Fe_2O_3, Al_2O_3	3·02
CaO	49·35
MgO	1·62
CO_2, H_2O, etc. (by difference)	39·33
TOTAL	100·00

The limestone is at present being worked for lime in several localities.

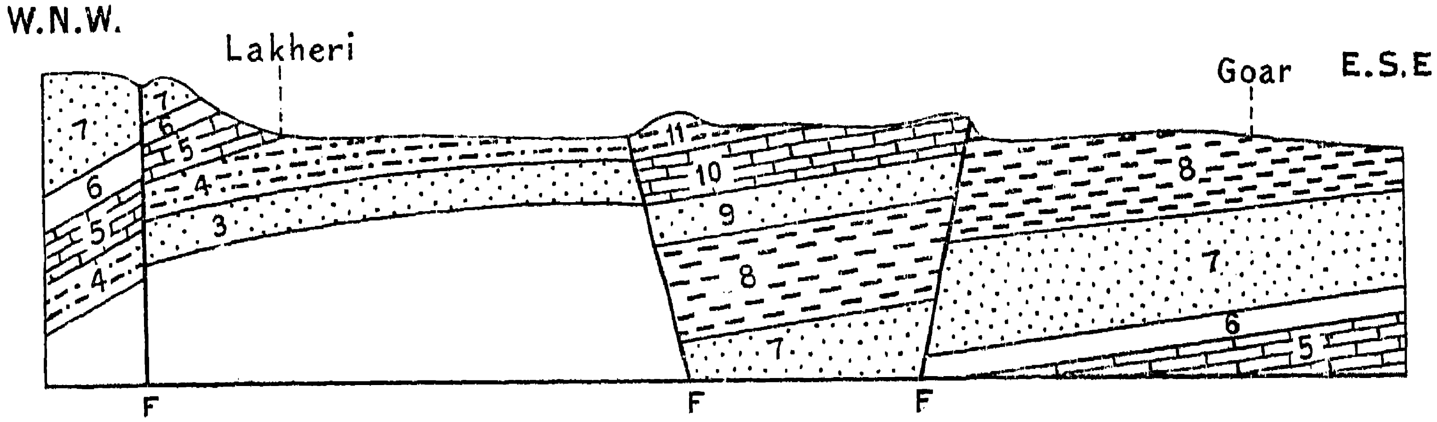


FIG. 8.—Section from Lakheri to Goar. For explanation, *see* Figs. 1 and 7.

It will be noticed that no limestone has been mapped as bordering the Upper Bhander sandstone on the north-eastern side of the ridge. Hacket's field maps show the limestone there and also further south on the same side; but, though it probably does exist further north, as the sandstone there is more anticlinal, it is masked by alluvium, and none could be found in the field.

Maps.

11. Upper Bhander Shales.

As has been stated, this is a new division and has not been described elsewhere. The shales conformably overlie the Upper Bhander lime stone (*see* figs. 7 and 8) and innumerable sections are to be seen along the banks of the tributary of the Sundal Nala which runs from Kuarpura, the river winding its way along the junction between the shales and the limestone.

A new division.

The shales resemble the other shales of the Upper Vindhyans, being fissile and ferruginous. The soil over the shales has a decided reddish colour. The shales occur in force on both sides of the railway line and also of the road from Indargarh to Lakheri. In the immediate neighbourhood of the north and south fault (*q. v.*) which cuts off these higher members of the Upper Vindhyans from the Ganurgarhs and the Lower Bhander limestone and sandstone, the Upper Bhander shales are somewhat disturbed.

Characteristics and extent.

Their thickness is about equal to that of the Upper Bhander limestone, *i.e.*, 180 to 200 feet. Towards the north, the dip flattens and the width of outcrop is correspondingly increased.

Thickness.

Grit and sandstone.

In the south-west the shales are capped by a series of grits sandstones and quartzites with intermediate shales. It was at first considered desirable to give a name to this facies but later it was decided to include it in the general term Upper Bhander shales. Hand specimens (34/467) of the grit show abundant angular and rounded fragments of quartz, both clear and reef, which, upon weathering, stand out from the finer-grained matrix. Neither red nor black jasper is present (*cf.* Kaimur conglomerate).

The dips of these sandstones are increased locally and on account of the discordancy in dips on the north-west corner of the little hill, the fault has been placed on the western side of the hill and the grits and sandstones incorporated with the Upper Bhander shales and not with the Ganurgarhs.

C. RECENT AND SUB-RECENT DEPOSITS.

Soil.

In the Vindhyan region, sandstone is the predominating rock type and the soil is light and sandy. In the valleys, where limestone and shales are developed, the soil is better and grows a variety of crops. The usual method of agriculture depends upon sub-soil water, the water being obtained from wells by means of leather bags elevated by cattle. The Persian wheel is not used in Bundi.

Vegetation.

Among the commonest trees and shrubs one mentions :—*salar* (*Boswellia serrata*), which grows on plateaux and dip slopes; *akra* (*Calotropis gigantea* or *C. procera*); *kareel* (*Capparis aphylla*); *bori* and *ber* (*Zizyphus jujuba* and *Z. nummularia*); *hingotia*; *khejra* (*Prosopis spicigera*); *goya*; *bikel*; *babul* or *kikar* (*Acacia arabica*); *nim* (*Melia azadirachta*); *khair* (*Acacia catechu*); *palas* or *chaura* (*Butea frondosa*); *hernia*; *pilu* or *jhal* (*Salvadora oleoides* and *S. persica*); *dhokra* (*Anogeissus pendula*); *orachl*; *bila* on the plateaux; *bar* or *banyan* (*Ficus bengalensis*); *gular* (*Ficus glomerata*); *pipal* (*Ficus religiosa*); *khajur* (*Phœnix sylvestris*); *imli* or tamarind (*Tamarindus indica*); *am* or mango (*Mangifera indica*).

The commonest jungle shrubs are the *dhokra* and *khair*.

Alluvium.

Alluvium covers a great area to the south of Bundi but, had time permitted, there is no doubt that the Sirbu shales could have been mapped over the greater part of this region.

North of the Vindhyan ridge, alluvium has been mapped over an area which is probably Gwalior shales, etc. It will also be noted that there is a patch of alluvium along the course of the Mej River through the Vindhyan hills, the same having been deposited by that river during its wanderings before it found a way through the last big sandstone ridge. There was, at this time, almost certainly a lake.

Conglomerate.

In the bed of the Mej River, just before it enters the hills at Ramgarh, a conglomerate is in the process of being formed. The cementing material of this rock is the lime derived from the Gwalior limestones which crop out in the river a short distance upstream, and the pebbles are blocks of Gwalior rocks washed down stream.

IV. STRUCTURE OF THE AREA.

Strike and dips.

The general strike of the Upper Vindhyan series in Bundi coincides with that of the Gwalior rocks to the north-west, *i.e*, approximately N.E.-S.W. The same pressure agencies which earlier caused the folding of the Aravallis, Delhis and Gwaliors were repeated at the close of the Upper Vindhyan period. As the Vindhyan rocks have been subjected to the last of these pressure agencies only, the resultant dips are far less than those of the more ancient systems and faulting, as distinct from folding, is the chief structural feature of the area.

Great boundary fault.

The fundamental structural feature of the area is the great fault which divides the Vindhyans from the ancient Gwalior rocks to the north. This persistent fault, with another parallel to it, has been traced to the north-east of the area by Dr. A. M. Heron.[1] The south-eastern of his faults, the Great Boundary Fault of Rajputana, as it has been called by Hacket, is considered to be a reversed fault, on which assumption the hade of the fault plane would be to the north-west. In Bundi the position of this fault cannot differ greatly from that of the shore line of the old Vindhyan sea, the only upper Vindhyan rocks found to the north-west being Kaimurs.

The Great Boundary Fault enters the area under discussion near Mohanpura, and here there is very complicated cross-faulting. First faulting the Sirbus against the Gwaliors, the Boundary Fault

[1] *Op. cit.*, pp. 130, 131; 169-177.

winds around the Lower Bhander sandstone hills to the west, and then continues more or less south-west to Antarda. Here it definitely divides into two, the field evidence being clear.

The northern fault separates the Lower Bhander sandstone from the Gwaliors and runs about west-north-west without interruption by Jaitpur Bhaironpura (25° 31′; 75° 43′), and Tikarde to Satur, where it suffers a displacement. From Satur the great fault continues with no interruption to Bhojgarh, where over a distance of about a mile it consists of several parallel faults.[1] The main fault, however, continues past Khenia till it passes out of Bundi into Mewar. It has thus been traced continuously for approximately 70 miles. To the north-east, Heron has traced it for almost 100 miles further and to the south-west the fault has been traced for 80 or 90 miles into Mewar. For practically the whole of its length in Bundi, the Great Boundary Fault has approximately a constant throw or overthrust as Lower Bhander sandstone and Sirbu shales, with one exception (Samria shales, near Talwas), are faulted against the Gwaliors. At Satur the limestone is faulted against the Gwaliors, but this is more likely the result of later cross-faulting.

There is no actual field evidence as to the nature of the Great Boundary Fault, *i.e.*, whether it be a reversed or a normal fault.

Reversed nature of the Great Boundary Fault.

If it be the latter, then the throw and hade are to the south-east. It is thought, however, that the thrust is from the north-west, and that the Gwaliors have risen relatively to the Vindhyans. Consequently the fault is treated in the sections as a reversed fault.

Near Tikarde the Lower Bhander sandstone begins to show a white quartzitic facies. Hence onwards the fault is probably in the

Datunda quartzite.

nature of a series of parallel faults with consequent hardening and metamorphosing of the sandstone. The quartzite is in appearance not very different from a white reef-quartz, and it has been mapped by Hacket as a Delhi quartzite. There appears to be no definite evidence for regarding it as other than an altered type of Lower Bhander sandstone. It is conformably underlain by Samria shales and in places the Sirbus overlie it.

East of Datunda, passing through the hills from north to south, one meets Gwalior shales, slates and limestone with white reef-quartz pegmatites; whitish quartzite; shales and slates, possibly

[1] *Cf.* Heron, *op. cit.*, p. 170.

Samria; reddish quartzite; Samria shales; Lower Bhander limestone. The repetition of the Samria shales is probably due to parallel faulting.

Another good section can be seen in the Deogarh valley near Datunda. Passing from the south-west to the north-east, one meets Gwalior shales, etc., with pegmatites; whitish Lower Bhander quartzite; grit (Lower Bhander); reddish quartzite (Lower Bhander); Samria shales; Lower Bhander limestone. The same grit in the Lower Bhanders may be picked up further to the south at Rupura. The white Datunda quartzite of the Bhojgarh district is well shown in Plate 16, fig. 2.

Other great faults.

It has already been stated that the main boundary fault divides into two at Antarda. The southern branch continues south-west for some 14 miles through Talwas and Motipura, finally dying out at the latter place. A sketch section of its relations has already been given. Between Chipalto and Motipura, this fault is joined by another which runs south-west from Putehpura.

About a mile east of Bhaironpura (25° 31′ : 75° 45′), the Great Boundary Fault is joined by a fault which commences near Ramgarh in the form of a horseshoe (*see* fig. 9). The upturned edges of the strata here are very conspicuous, though the throw of the fault is very small to begin with, the Lower Bhander sandstone being faulted against the next lowest bed, the Samria shales. After the fault turns south-west, the throw increases and we have limestone against Sirbu shales. Three sections across the fault are given below. The first section, that near Pipla shows an almost overhanging hill of Lower Bhander sandstone. Towards the west-south-west the sandstone is more evenly folded and in the last section the rocks are all tilted to the north-north-west.

The fault no doubt continues south-west as shown, though alluvium masks the outcrops; it finally joins with the great boundary fault near Bhaironpura. Near Ramgarh, on the west side of the Mej River, a dislocation in the Lower Bhander sandstone can be plainly seen. Also, near "Rock 1231" several minor faults can be plainly seen in the Lower Bhander sandstone.

Near Mohanpura, as has been stated, several minor faults are observable. One lies on the north and another on the south side of "Height Station 1519" and these meet with a third, which crosses the road from Mohanpura to the plains to the west. Near

this village, also, another great fault joins with the great boundary fault, and continues south-west, with minor deviations, by

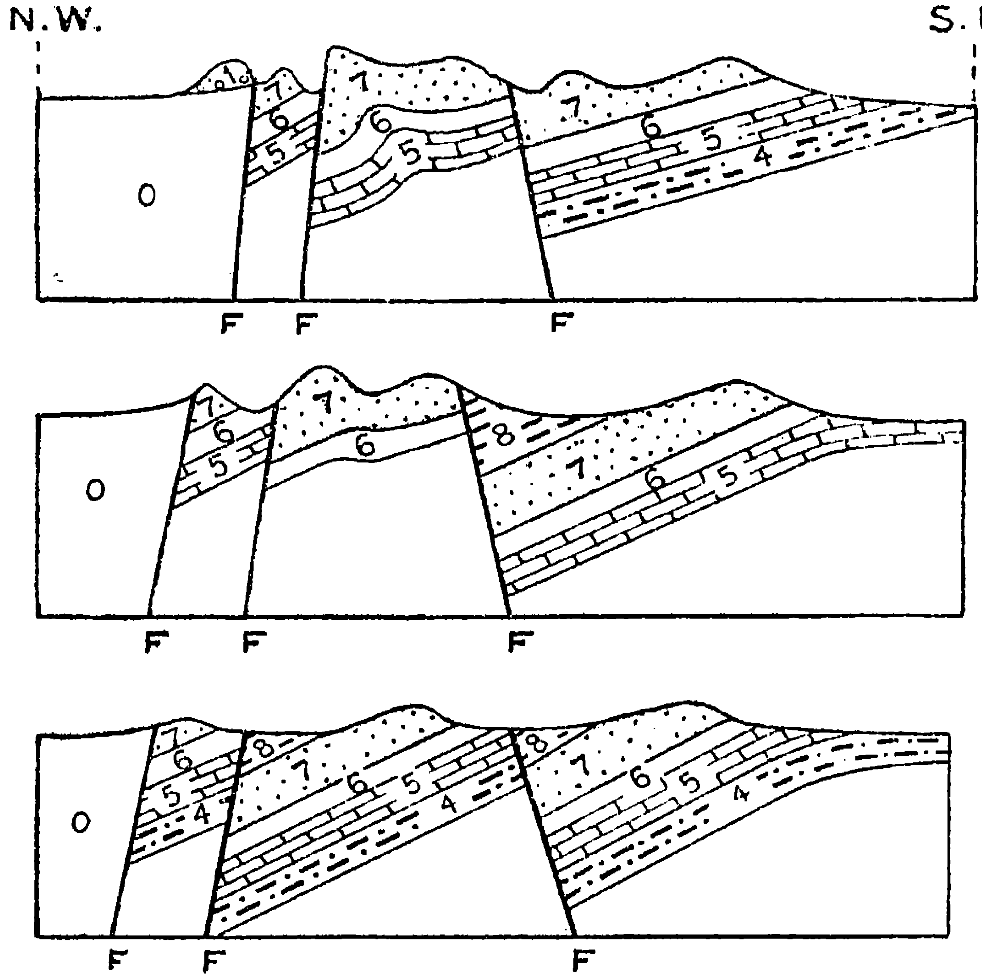


FIG. 9.—Ramgarh Horseshoe Fault. For explanation, *see* Fig. 1.

Indargarh, Sabalpura, etc., to Bundi, finally dying out near Suraj Chatri, a distance in all of 40 miles. This fault has a very great throw as, for practically the whole of its length, Jhiri and Panna shales are against Lower Bhander sandstone. At Suraj Chatri it ends in Ganurgarh shales. A cross-fault truncates the Lower Bhander ridge at Bundi.

Masked by the alluvium to the south of the Bundi-Lakheri ridge, there is obviously some fault which brings the Ganurgarh shales against the Sirbus. In its northern portion, this fault is shown by the horseshoe fault separating the Ganurgarhs from the Upper Bhander shales near Lakheri. Near this town the faulting is greatly complicated. In the ridge immediately north-west of Lakheri, there is a local breaking in the Lower Bhander sandstone,

the throw of which break increases as it is followed to the north and east, where it is finally lost in the alluvium. This fault branches near "Pole" and joins up with the Indargarh-Bundi fault and the main boundary fault. The horseshoe fault above mentioned begins west of Balsunda and dies out at the foot of the Upper Bhander sandstone ridge near Goar.

An interesting region is the range of hills lying at the foot of the great Lower Bhander scarp of Bundi-Lakheri between Khatkar and Arjipura (*see* fig. 10). Here we appear to have the complete succession from south to north as follows :—Lower Rewah sandstone ; Jhiri shales ; Upper Rewah sandstone ; Ganurgarh shales ; Lower Bhander limestone ; sandstone ; Samria shales ; Lower Bhander sandstone. The sandstone following the Lower Bhander limestone is either a faulted outlier of the Lower Bhander sandstone or a lenticular sandstone deposit between the Samria shales and the Lower Bhander limestone. It has been regarded as the former since the Samria shales and Lower Bhander limestone are developed in force at the foot of the scarp, and in no other places have traces of a lenticular deposit in between these series been found. Again, the strata in the neighbourhood of Arjipura are very disturbed, especially in the pass through the hills one mile to the west-south-west. A sketch section showing the relations is given below (fig. 10) :—

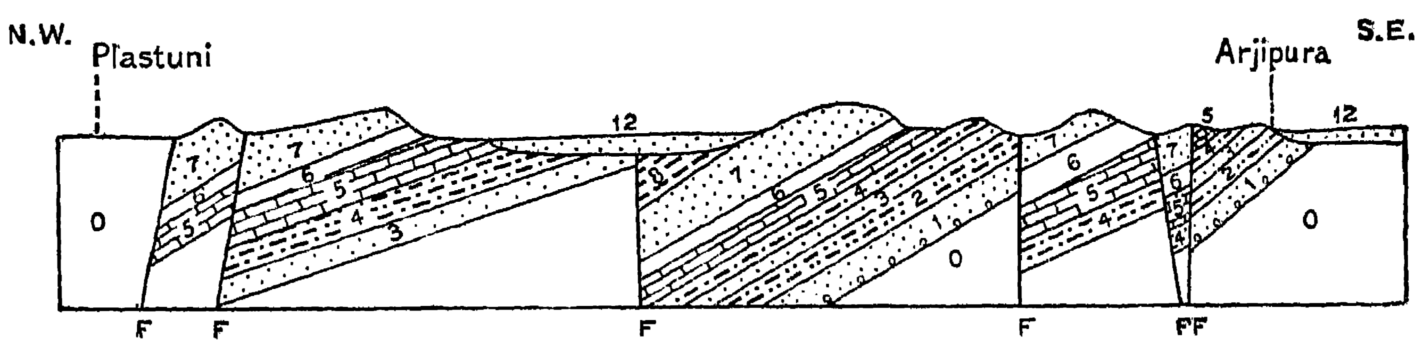


FIG. 10.—Section from Plastuni to Arjipura. For explanation, *see* Fig. 1.

Folding.

Towards the south faulting is less important and the rocks have been folded as the result of less intense pressure. Gently dipping synclines and anticlines are common. South-east of Khenia and about 12 miles south of Bundi, the strata are gently undulating and the geology is comparatively simple. Sketch sections of the Satur anticline and Nimka Khera syncline have already been given.

V. ECONOMIC RESOURCES.

Building-stones: Upper Bhander sandstone.

The usual building-stone of the Upper Vindhyans is the Upper Bhander sandstone. In the Bundi area this deposit was found only in the extreme north-east where, as it is well jointed and bedded, it is quarried to a small extent. It is, however, situated too far away from any of the bigger towns in Bundi, except Lakheri, for quarrying on a large scale, and in Lakheri the limestone, being more easily worked and extensively quarried for lime and cement, is the usual building-stone.

Lower Bhander sandstone.

The predominant sandstone of the Upper Vindhyans in Bundi is the Lower Bhander sandstone and this has been employed greatly as a building-stone. One of the chief quarries in this sandstone is situated 2 miles north-west of Umarthuna the stone from this locality being used in Bundi for roofing and flooring purposes. The beds dip south-east at about 30°. The stone is generally blasted and then removed by bullock carts along a bad track to Bundi. For slabs 10 feet square and from 1 to 2 inches thick, the cost varies from Rs. 15 to Rs. 20. Other quarries are to be seen along the southern slopes of the sandstone south-west of Bundi. The rocks have a fairly constant dip of about 30° and the illustration (Plate 16, fig. 1) shows the dip slopes utilized by the streams as their beds.

Lower Bhauder limestone, etc.

The limestone, as has been stated, is extensively used for local building purposes. The Upper Rewah sandtone, when flaggy and micaceous, is also employed.

Gwalior building-stones.

Near Datunda there is a large quarry, styled the *Hathi Bur* on account of the resistance to fracture of the slabs quarried when trodden upon by an elephant in olden times. Here there are shaly limestones dipping at 50° to the north-west and the cost of slabs 8 by 2 feet and from 4 to 6 inches thick is Rs. 4 per slab. These slabs have been employed in Hindoli, Bundi and Barodhia.

Between Bundi and Shikarburaj, there are several wonderfully carved tombs which have been built of marble obtained locally. This generally comes from Umar in the north of the State. This stone, which is almost a marble, takes a really fine polish and extraordinarily fin› carving can be wrought upon it. Ordinarily

however, the stone is used unpolished and the Vindhyan limestones sufficiently serve the local needs.

Copper.

Copper ores have been noted at Neagaon with quartz and calcite.

Two miles west of Narenpur there are two old pits which were dug when copper was mined from the locality. The ore consisted chiefly of malachite and azurite (16417; 16418) in impregnated Gwalior shales. The copper ores were deposited from solutions accompanying a reef-quartz pegmatite.

One mile north-west of Gudha in two hills bordering the Belindi Nala, copper ores were quarried some 80 years ago, but work was suspended on account of a disagreement between Mewar and Bundi as to whose territory the deposit belonged. The matter was eventually decided in favour of Bundi. The amount of ore present is very small and totally insufficient to repay working expenses.

Iron Ores : Lower Bhander sandstone.

Occasional hæmatitic and limonitic boulders have been noted upon the slopes of the Lower Bhander and other Vindhyan sandstones. Usually, such are also slightly manganiferous but they have no economic value and their occurrence is recorded merely for completeness.

Jhiri shales and Upper Rewah sandstone.

Iron oxide in the form of hæmatite and limonite occurs at the junction of the Jhiri shales with the Upper Rewah sandstone, and this is the chief source of supply from Vindhyan rocks for the local iron workers. There are small pits in the neighbourhood of Loharpura (25° 28′ : 75° 4[illegible]′), Bhaironpura (25° 31′ : 75° 43′), Loharpura (25° 33′ : 75° 55′), etc. The iron is extracted locally and is utilised by the villagers for the manufacture of carts, etc.

Gwaliors.

In the Gwalior rocks there are several old mines from which iron has been mined for many hundreds of years. The chief of these are at Umar, Khenia, Narenpur and Datunda. The usual ore is an ochriferous hæmatite and limonite.[1] The mine at Khenia is stated to be of a tremendous size but it was not possible to inspect it. The usual method of origin, that of metasomatic replacement of the original Gwaliors by solutions from the pegmatites, is generally applicable. The supply and quality of the ore is totally insufficient for modern purposes.

[1] *Rec., Geol. Surv. Ind.*, LVIII, pt. 1, p. 28.

On account of the great distance that coal would also have to be carried, it is certain that, in view of present day costs, a profitable working of the iron ores of Bundi could not be carried out.

Kaolin.

At Manak Chok again at the junction of the Upper Rewah sandstone with the Jhiri shales, there are a few pits from which kaolin (34/465) has been dug. It is impure and earthy and rather dirty in colour and has been formed through the decomposition of aluminous material in the shales and sandstone. Though it has no great economic value, it is used locally for white-washing villagers' houses.

Limestone.

The Lower Bhander limestone is the chief deposit of economic interest in the Upper Vindhyans. It is at present being extensively quarried for both lime and cement at the Bundi Portland Cement Works at Lakheri. The structure of the quarry area is simple. The sequence is the normal one of Ganurgarh shales, Lower Bhander limestone, Samria shales and Lower Bhander sandstone in the form of a pitching anticline, the general dip varying from north-west to north and north-east. The amount of dip is quite small and is usually about 5°. About a mile north-east of Lakheri, the dips become very steep and the limestone bands are repeated. Several trial pits have been sunk by the company at the foot of the hill east of the quarry and all show limestone, which, of course, is the same Lower Bhander limestone as that being quarried on the level ground to the south-west.

At the head of the valley south of "Pole," the limestone outcrop is masked by thick screes. As one rises up this valley also, one meets with Samria shales. These are faulted against the Lower Bhander sandstone to the west, but the throw of the fault is not very great, since due west of Lakheri the fault merely displaces the Lower Bhander sandstone, the junction between the Samria shales and the sandstone being a perfectly normal and conformable one. The fault, which is a hinge fault, with a greater displacement to the north, commences just south-west of Lakheri, runs north-east to "Pole" and there turns east and is lost in the alluvium.

The limestone that is being worked at Lakheri can be traced as far south-west as the Mira Sab ka Dongar, near Bundi, a distance of 37 miles. On the east, it is cut off by a fault running more or less north and south, about 1½ miles east of Lakheri. The Lower Bhander limestone is not found east of this line. The little hills

two miles south-east of Lakheri are formed of highly puckered Ganurgarh shales and the fault must run near these. The Sirbu shales of Balapura are probably faulted against the Ganurgarhs but alluvium masks the outcrops.

Composition of the limestone.

It is a matter of extreme importance to the Bundi Portland Cement Works to know the exact composition and lateral variation of each band in the limestone. Numerous analyses have been made by the chemist to the company, Mr. A. Weighell, and the figures of some of the lime quarry and cement quarry analyses have been kindly supplied by the Managing Agents Messrs. Killick, Nixon & Company.

Lime Quarry Samples.

	Red Floor.	White.	Top Red.
Number of analyses.	3	7	7
SiO_2 (calcined)	27·12	22·77	23·01
SiO_2	18·32	14·67	14·97
Al_2O_3	4·64	3·34	3·09
Fe_2O_3	1·76	0·53	0·94
CaO	41·53	44·88	44·74
MgO	0·93	0·75	0·74
CO_2	31·37	34·73	34·61
Combined H_2O	0·82	0·73	0·73
TOTAL .	99·37	99·63	99·82
Calcimeter figure	71·2	78·9	78·7
Ratio $\frac{SiO_2}{Al_2O_3}$	3·97	4·40	4·84

Cement Quarry Samples.

Bench numbers.	1	2	3	4
Number of analyses.	10	10	10	5
SiO_2 (calcined) . . .	25·85	24·06	25·58	26·60
SiO_2	16·98	15·68	16·87	17·85
Al_2O_3	3·01	3·19	3·86	3·84
Fe_2O_3 . . .	0·94	1·19	1·24	1·63
CaO	43·36	43·71	42·56	42·11
MgO	1·03	1·09	1·06	1·24
CO_2	33·33	33·74	32·94	31·80
H_2O etc.	1·00	1·05	1·05	1·02
TOTAL .	99·65	99·65	99·58	99·49
Calcimeter figure . . .	75·7	76·6	74·9	72·2
Ratio $\frac{SiO_2}{Al_2O_3}$	5·64	4·91	4·37	4·65

An examination of the above analyses shows that the limestone is fairly pure. There are, however, occasional dolomitic veins which are secondary in origin. These contain up to 12 per cent $MgCO_3$ with the calcite. The basal bed of the limestone, that resting upon the Ganurgarh shales, is more dolomitic than the other limestone beds and also more gritty. The origin of the dolomitic veins is undoubtedly metasomatic replacement of the calcite of the original deposit.[1] Of the three other methods of formation of dolomite, *viz.*, by chemical precipitate, by clastic deposition, and by the differential leaching of slightly magnesian limestones in carbonated waters, none is applicable in the present case by the very nature of the occurrences in veins.

Dolomitic veins.

[1] "The Formation of Dolomite and its Bearing on the Coral Reef Problem." E. W. Keats, *Am. Journ. Sci.*, XLV, March, 1918, pp. 191-193.

Bundi Portland Cement Works.

The Bundi Portland Cement Works have a modern plant with every possible labour-saving device (*see* Plate 20.). They have recently installed a new crushing plant and the output of the works is likely to be considerably increased in consequence. The stone reserves of the company are immense, but the overburden is increasing as the quarries are extended to the north. Though at present scoops have to be utilized, there are many years reserves in actual sight. The company have the sole rights for limestone in Bundi State.

The Upper Bhander limestone is somewhat similar in appearance to the Lower Bhander limestone and an analysis of it has already been given. It will be seen that this limestone contains less impurities (SiO_2, Al_2O_3, Fe_2O_3) and slightly more magnesia than the Lower Bhander limestone. It is a good stone for lime and, being almost horizontal and with a negligible overburden on practically the whole extent of the outcrop, can be utilized in the future if necessary. At present, the Mej River is dammed at Shekaoda (*see* Plate 19, fig 1) and water is pumped up from the village over the range of Upper Bhander sandstone which runs from Shekaoda north-east into Kotah and Jaipur. The foundations of the dam are on Sirbu shales which are here practically horizontal.

Figures showing the output of lime and cement from Lakheri for the 7 years 1917 to 1923 are given in the following table[1] :—

[1] By kind permission of Messrs. Killick, Nixon & Co.

Output of Lime and Cement from Lakheri.

	1917.	1918.	1919.	1920.	1921.	1922.	1923.	Total.
	Tons	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Stone for Cement-making . . .	36,946	46,293	63,177	81,683	1,21,877	1,19,876	1,26,135	5,95,987
Stone for Lime-burning . . .	7,047	9,850	895	..	..	828	450	19,070
Cement output . . .	19,178	29,854	32,740	36,339	60,100	55,227	57,055	2,90,493
Lime output	3,495	6,809	630	..	..	388	157	11,479
Coal consumption	9,698	14,542	17,536	18,970	35,203	35,593	35,544	1,67,086
Gypsum consumption . . .	383	597	655	727	1,211	1,104	1,140	2,817

The results of tests on the cement made by Messrs. Henry Faija & Company, London, and the Government Test House, Alipore, Calcutta, are given below.

Results of Tests by Messrs. Henry Faija & Co., on a sample of Portland Cement 28th July, 1922.

	British Standard Specification Requirements.	Results of Tests on Sample.
Fineness.		
Residue on 180×180 mesh sieve	Maximum 14 per cent.	7·3 per cent.
" " 76×76 mesh sieve	Maximum 1 per cent.	*Nil.*
Setting time.		
Initial	Minimum 20 mins .	2 hours.
Final	Maximum 10 hours	6 "
Soundness (Le Chatelier Method).		
Maximum Expansion—		
After 24 hours' aeration	10 mm.	0 mm.
After 7 days' aeration	5 mm.	0 mm.
Chemical Analysis.		
Water and Carbonic Anhydride	Not exceeding 3 per cent.	1·49
Insoluble Residue	Not exceeding 1·5 per cent.	·69
Silica	....	24·27
Alumina	....	5·00
Oxide of Iron	....	1·68
Lime	....	63·37
Magnesia	Not exceeding 3 per cent.	1·50
Sulphuric Anhydride (total sulphur calculated as)	Not exceeding 2·75 per cent.	1·67
Alkalies and loss	....	·15
TOTAL .	....	100·00

Tensile Tests.

Neat Cement.			3 parts of Sand to 1 part of Cement.		
Times of Setting.			Times of Setting.		
7 days.	28 days.	3 months.	7 days.	28 days.	3 months.
lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.
640	800	920	290	470	515
590	760	850	270	460	530
630	840	880	260	440	555
620	815	910	255	450	570
580	830	880	290	420	585
575	840	870	280	445	580
Average 606	814	885	274	447	556

Compression Tests.

Neat Cement.			3 parts of Sand to 1 part of Cement.		
Times of Setting.			Times of Setting.		
7 days.	28 days.	3 months.	7 days.	28 days.	3 months.
lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.
5,806	8,443	12,139	2,269	4,902	5,809
6,157	8,443	11,258	2,360	4,702	6,445
5,278	8,091	12,313	2,269	4,881	5,809
5,453	7,739	12,843	2,269	4,448	6,445
5,453	9,147	11,787	2,269	4,531	6,717
5,630	8,091	12,665	2,178	4,448	6,354
Average 5,630	8,326	12,167	2,269	4,655	6,263

Tests on Cement Samples sent to the Government Test House, Alipore, during the year 1923.

Month.	RESIDUE ON		Expansion.	SETTING TIME				TENSILE STRENGTH IN LBS. PER SQ. IN.				Percentage of water used for gauging.	
	76-mesh sieve.	180-mesh sieve.		Initial.		Final.		Neat Cement.		3 parts of Sand to 1 part of Cement.		Neat Cement.	Cement and Sand.
								7 days.	28 days.	7 days.	28 days.		
	Per cent.	Per cent.	mm.	hr.	mn.	hr.	mn.						
January . . .	0·20	9·95	1	0	55	4	45	627	791	272	323	20·0	8·0
February . . .	0·24	10·70	½	1	35	2	40	669	674	298	364	20·5	8·0
March . . .	0·09	6·99	1½	0	46	1	32	659	735	305	386	21·5	8·0
April . . .	0·08	7·03	1	0	38	1	50	708	734	319	362	21·0	8·25
May . . .	0·12	7·32	½	1	54	2	52	757	770	336	391	21·0	8·0
June . . .	0·20	7·40	1½	1	47	3	1	766	787	328	405	21·0	8·0
July . . .	0·08	10·68	½	1	29	2	44	654	763	300	418	20·5	8·0
August . . .	0·08	10·36	½	1	12	1	58	736	806	365	412	19·5	7·5
September . . .	0·05	7·27	½	2	26	3	26	678	771	316	424	20·0	7·75
October . . .	0·15	10·47	1	2	32	3	22	673	741	298	423	20·0	8·0
November . . .	0·12	6·48	½	2	14	3	12	684	769	324	421	19·5	7·5
December . . .	0·15	6·17	½	1	15	2	4	704	838	291	406	20·0	7·75

Though the company have the sole rights for limestone in Bundi State, a lot of burning for lime in a small way is carried on by local contractors. Numerous deserted kilns may be seen on almost every outcrop of limestone, showing that before the advent of the factory, lime-burning was quite a big local industry.

Ochres.

The hæmatitic and limonitic ores mentioned as occurring at the junction of the Jhiri shales and the Upper Rewah sandstone are usually accompanied by yellow and purple ochres. These form the less ferruginous ores and are locally used for painting. Such ochres are also commonly associated with the iron ores found in Gwalior rocks.

Quartz.

Reef-quartz, if pure, has a commercial application in certain industries. In Bundi, to the north of the Vindhyan ranges, there are innumerable white reef-quartz pegmatites but such usually contain felspar. Near the bigger villages, however, they are less frequent, and as, apart from the one big road from Nasirabad to Deoli and Bundi, the roads are mere tracks, it does not appear likely that the purer deposits will be quarried. These reef-quartz pegmatites belong to the last phase of igneous activity before the Vindhyans and so they do not intrude these rocks.

Silica Sands.

About a mile south of Barodhia there is a grit which consists almost entirely of silica grains. It crumbles to sand on the application of very slight pressure and under the microscope there appears to be an absence of cementing materials (16415). It is the same grit as has been noted to occur in various sections of the white quartzite (Lower Bhander) near Datunda and Rupura. Its special virtue is the apparent purity of the grit.

For many years, though not at the present time, Barodhia was the centre of a glass-making industry and the source of supply was this grit. It has added interest in view of the proposal to establish a modern glass works and utilize the grit in the manufacture.

Interbedded with the white Lower Bhander quartzite are the grit and some shales. There is a good section along the road which passes through the range of quartzite. The grit is of fair dimensions, as could be seen from three pits which have been dug, only one of which was clear at the time of inspection. The quartzite here is above and below the grit and appears to be the same rock but more hardened and containing cementing material. It, too, will crumble

is sufficient force be used. The width of the grit is some 20 or 30 yards and its lateral extent is about 100 yards or more, though it has been proved only for a distance of some 20 yards. It dips at about 70° to 80° under the quartzite.

The supply of grit would have to be proved by pits or boring before it could be developed on any scale ; the high dip to the north, would also have an adverse effect on the value of the deposit. Samples would have to be analysed to prove their freedom from iron etc., before any work took place.

Tourmaline, Garnets, etc. Tourmaline is common in certain of the pegmatites but has no economic value.

Garnets occur in certain Gwalior schists in the north-west corner of the State, but are of no use as gem-stones.

VI. SUMMARY.

The Upper Vindhyan groups occurring in Bundi have been described at some length. Of these, two new divisions of the Upper Bhanders, namely, the "Upper Bhander limestone" and the "Upper Bhander shales," have been recorded. The Lower Bhander sandstone is the dominant rock of the area and attains a thickness of about 2,600 feet.

Economically, the Lower Bhander limestone has great importance. It is being worked at Lakheri by the Bundi Portland Cement Works for lime and cement. The author wishes to record his sincere thanks to Mr. E. Christensen, Manager of the works at Lakheri, for his courtesy in giving Mr. Bradshaw and himself every facility for the examination of the quarries and works, and to Messrs. Killick Nixon & Co. for analyses of the limestone and output figures, and for the loan of blocks forming Plates 19 and 20.

The Upper Bhander limestone appears to offer great economic possibilities.

VII. LIST OF PLATES.

PLATE 15, Fig. 1.—Exit of the Mej River from the Khatkar Hills, showing a fine dip-slope of Bhander sandstone.

„ Fig. 2.—Fault scarp of the Lower Bhander sandstone at Jhar. The illustration shows a waterfall, the level of the valley behind the scarp being at a higher level than the plain to the south.

„ 16, Fig. 1.—Dip-slope of Lower Bhander sandstone making the river bed, near Astoli.

„ Fig. 2.—Datunda Quartzite, from Bhojgarh.

Plate 17, Fig. 1.—Kaimur conglomerate.
,, Fig. 2.—Dhaneum boulder bed.
,, 18.—Concretion-marked Limestone, Satur.
,, 19, Fig. 1.—Dam across the Mej River at Shekaoda.
,, Fig. 2.—General view of quarries at Lakheri.
,, 20, Fig. 1.—The Bundi Portland Cement Works, Lakheri (looking west).
,, Fig. 2.—Rotary kilns, Bundi Portland Cement Works, Lakheri.
,, 21.—Geological map of Bundi State ; scale 1 inch = 4 miles.
,, 22.—Geological Map of part of Bundi State; scale 1 inch = 1 mile.

VIII. LOCALITY INDEX.

Locality.	N. Latitude.		E. Longitude.	
	°	′	°	′
Akoda Height Station	25	31	75	40
Antarda	25	40	76	6
Arjipura	25	31	75	54
Balwan	25	42	76	17
Balsunda	25	42	76	13
Balapura	25	38	76	13
Barodhia	25	29	75	35
Baklo	25	41	76	15
Bhaironpura	25	31	75	43
Bhaironpura	25	40	76	8
Bhojgarh	25	21	75	24
Borupurio	25	35	76	0
Borkhandi	25	28	75	36
Bundi	25	27	75	39
Chipalto	25	34	76	0
Chatarpura	25	43	76	11
Dalelpur	25	28	75	39
Daolatpura	25	24	75	35

Locality.	N. Latitude.		E. Longitude.	
	°	′	°	′
Datunda	25	27	75	28
Deogarh	25	26	75	26
Dhaneum	25	38	76	1
Gendoli	25	33	76	0
Goar	25	38	76	15
Goar	25	39	76	14
Gudha	25	36	75	54
Gudha	25	31	75	48
Indargarh	25	44	76	12
Jaitpur	25	37	75	59
Jhar	25	29	75	45
Kararkhera	25	34	75	32
Khatkar	25	30	75	51
Khenia	25	20	75	23
Khodi	25	44	75	46
Kotri	25	42	76	11
Lakheri	25	40	76	10
Loari	25	39	75	24
Loharpura	25	28	75	40
Loharpura	25	33	75	55
Manak Chok	25	33	75	54
Mohanpura	25	44	76	11
Motipura	25	34	75	56
Narenpur	25	28	75	30
Neagaon	25	30	75	31
Nim ka Khera	25	20	75	29

Locality.	N. Latitude.		E. Longitude.	
	°	′	°	′
Pagara	25	43	75	32
Pipla	25	35	75	58
Putehpura	25	36	76	0
Ramgarh	25	34	75	54
"Rock 1231".	25	33	75	51
Rupura	25	24	75	25
Sabalpura	25	33	75	56
Samria	25	6	75	7
Satur	25	28	75	34
Satur Height Station	25	26	75	30
Shekaoda	25	40	76	15
Sheria	25	38	76	6
Shikarburaj	25	28	75	40
Suturio	25	35	75	59
Talwas	25	37	76	3
Thalera	25	19	75	44
Tikarde	25	29	75	38
Umar	25	41	75	28
Umarthuna	25	24	75	31

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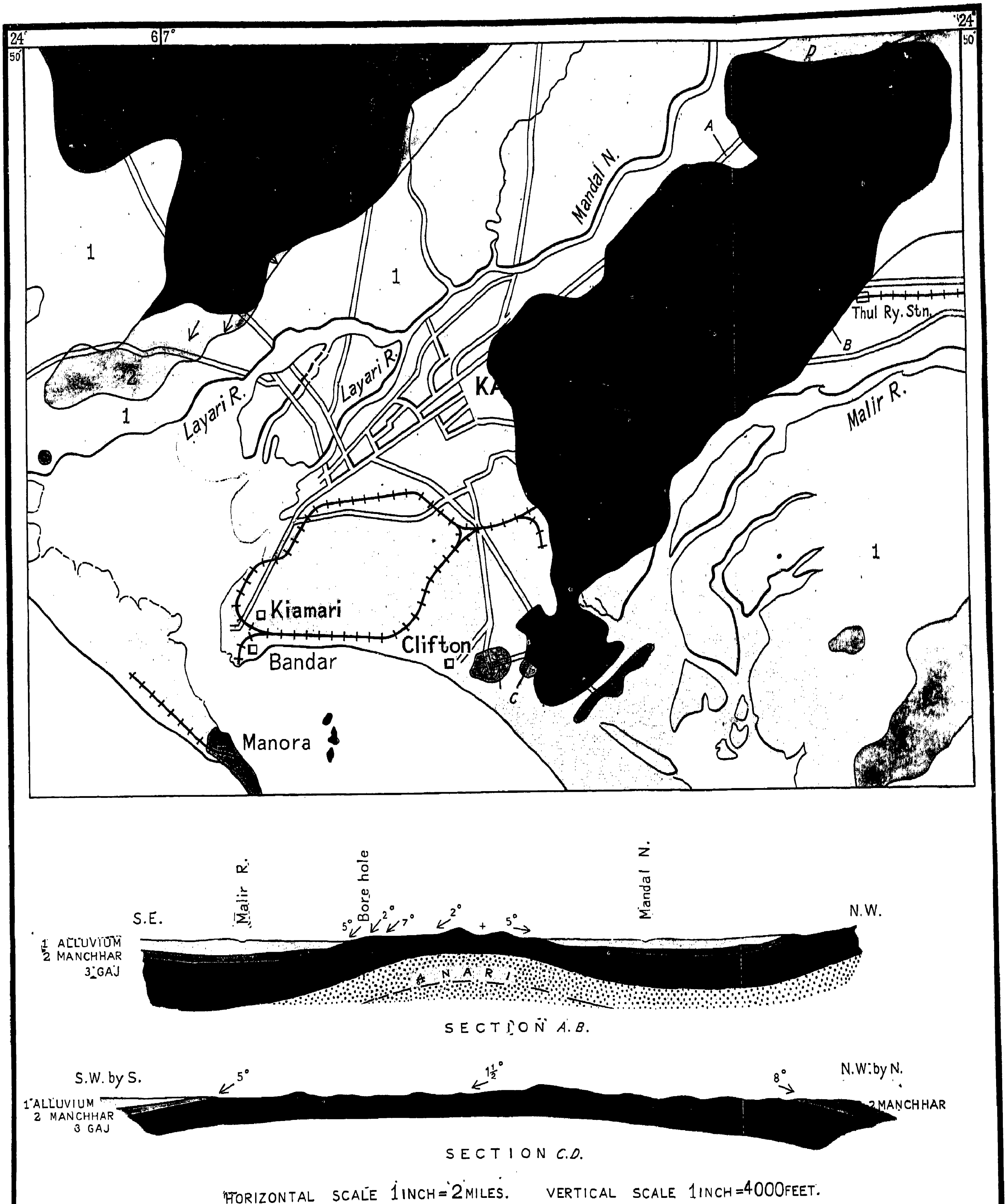


H. Crookshank. G. S. I. Calcutta.

GEOLOGICAL MAP OF KARACHI AND NEIGHBOURHOOD.

Scale 1 inch = 2 miles.

Fig. 1.

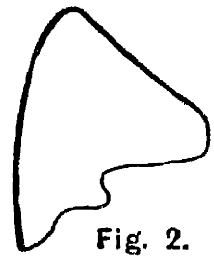


Fig. 2.

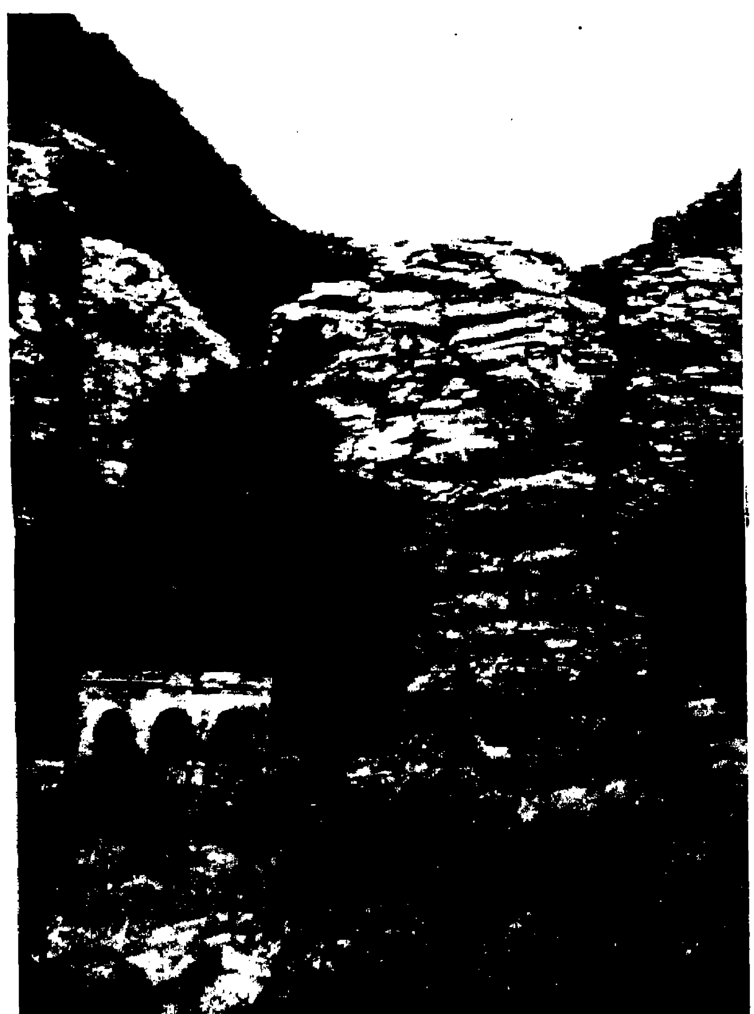
S. N. GUINE, *del.*

G. S. I. Calcutta.

TETRACONODON MINOR, Pilg.

Lower jaw and a cross-section of the canine, *(natural size.)*

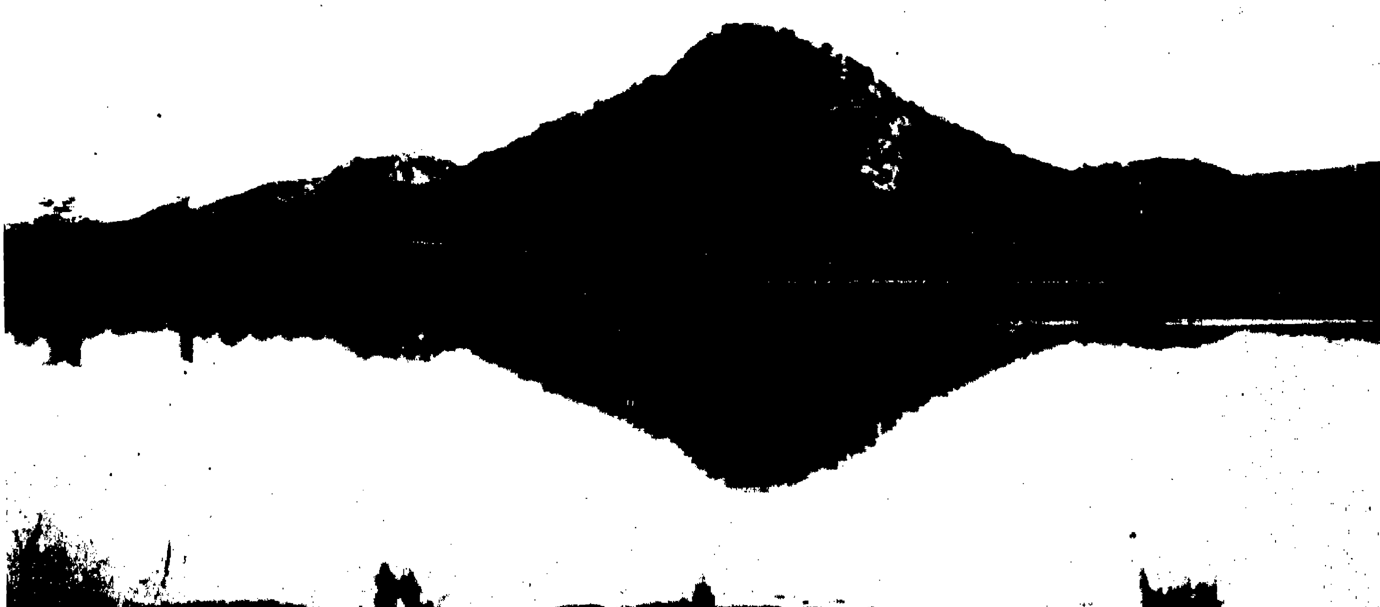
FIG. 1. EXIT OF THE MEJ RIVER FROM THE KHATKAR HILLS, showing a fine dip slope of Lower Bhander Sandstone.



A. L. Coulson, Photos. *G. S. I. Calcutta.*

FIG. 2. FAULT SCARP OF THE LOWER BHANDER SANDSTONE AT JHAR.

FIG. 1. DIP SLOPE OF LOWER BHANDER SANDSTONE FORMING RIVER BED, NEAR ASTOLI.



A. L. Coulson & A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. DATUNDA QUARTZITE, FROM BHOJGARH.

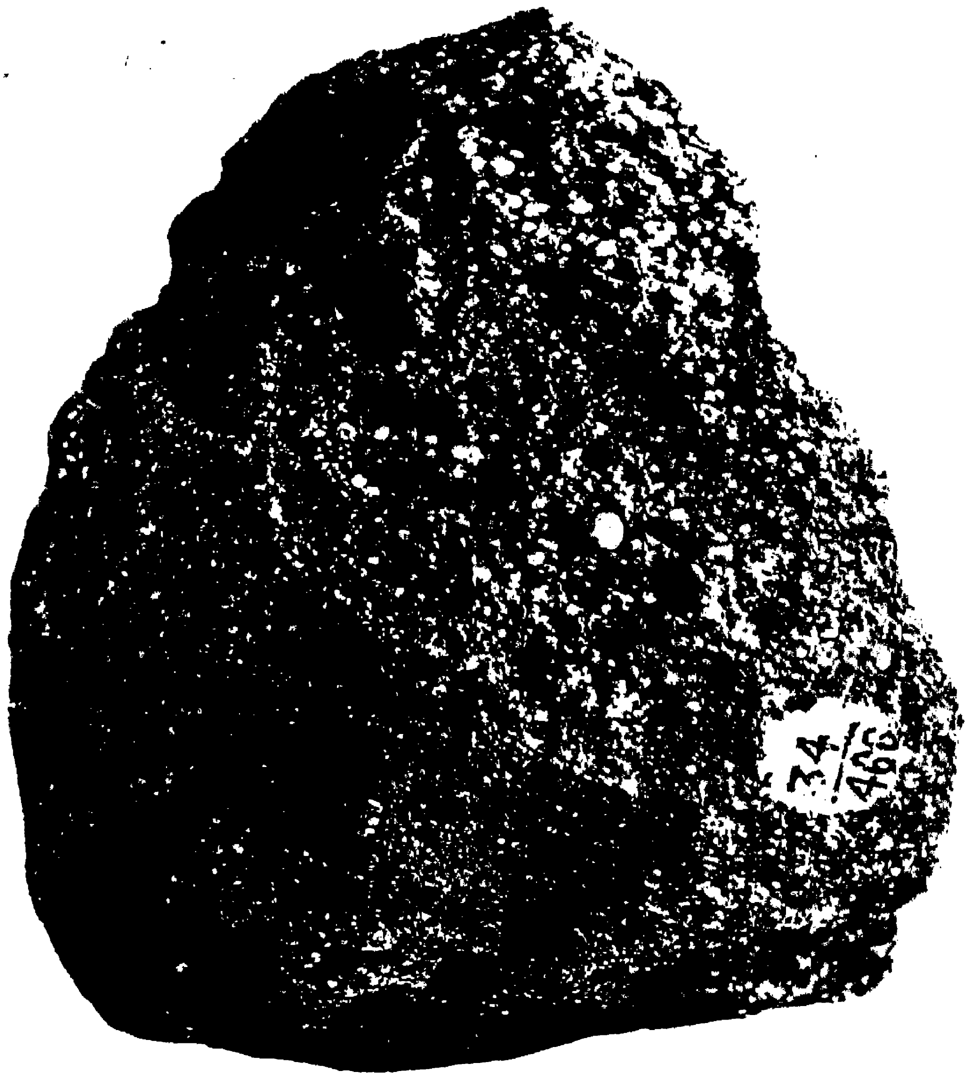
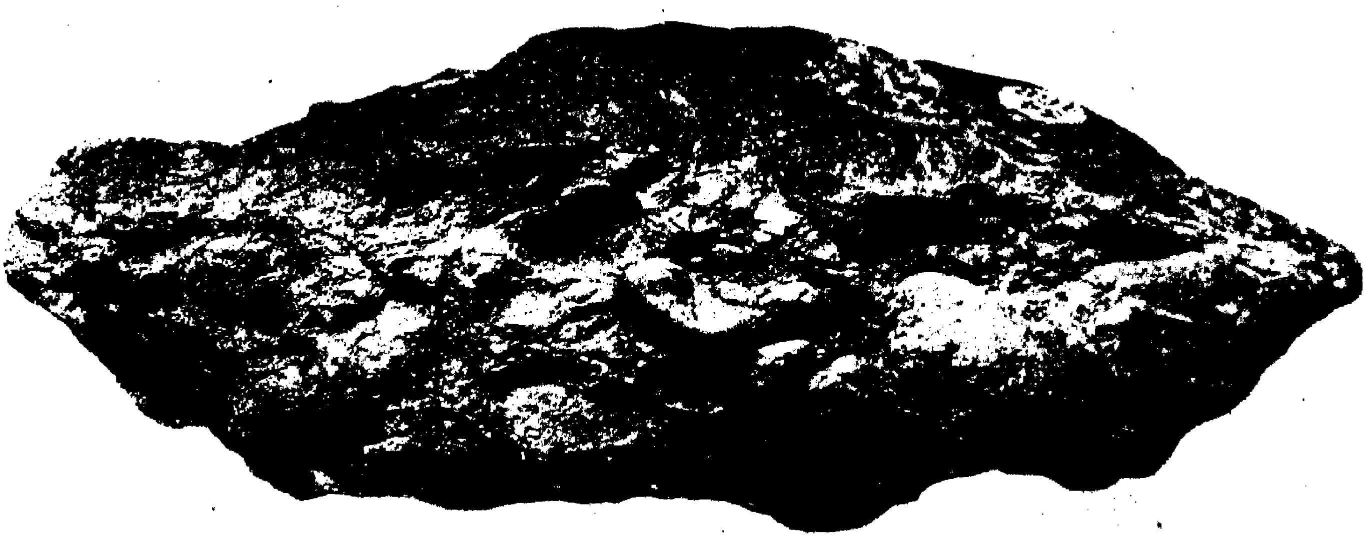


FIG. 1. KAIMUR CONGLOMERATE.



P. L. Datt, Photos. *G. S. I. Calcutta.*

FIG. 2. DHANEUM CONGLOMERATE.

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P. L. Datt, Photo. *G. S. I. Calcutta.*

CONCRETIONARY-MARKED LIMESTONE, SATUR.

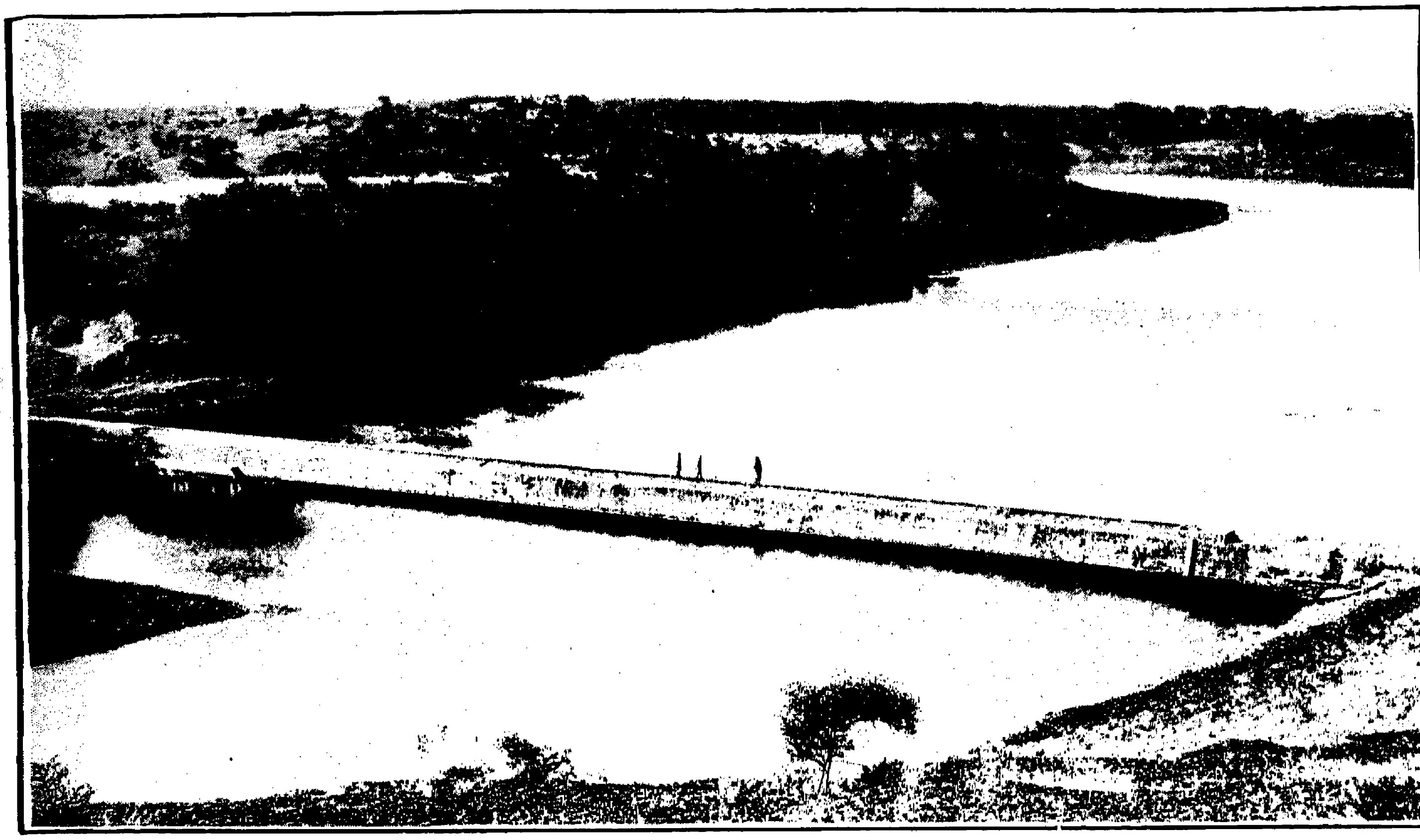
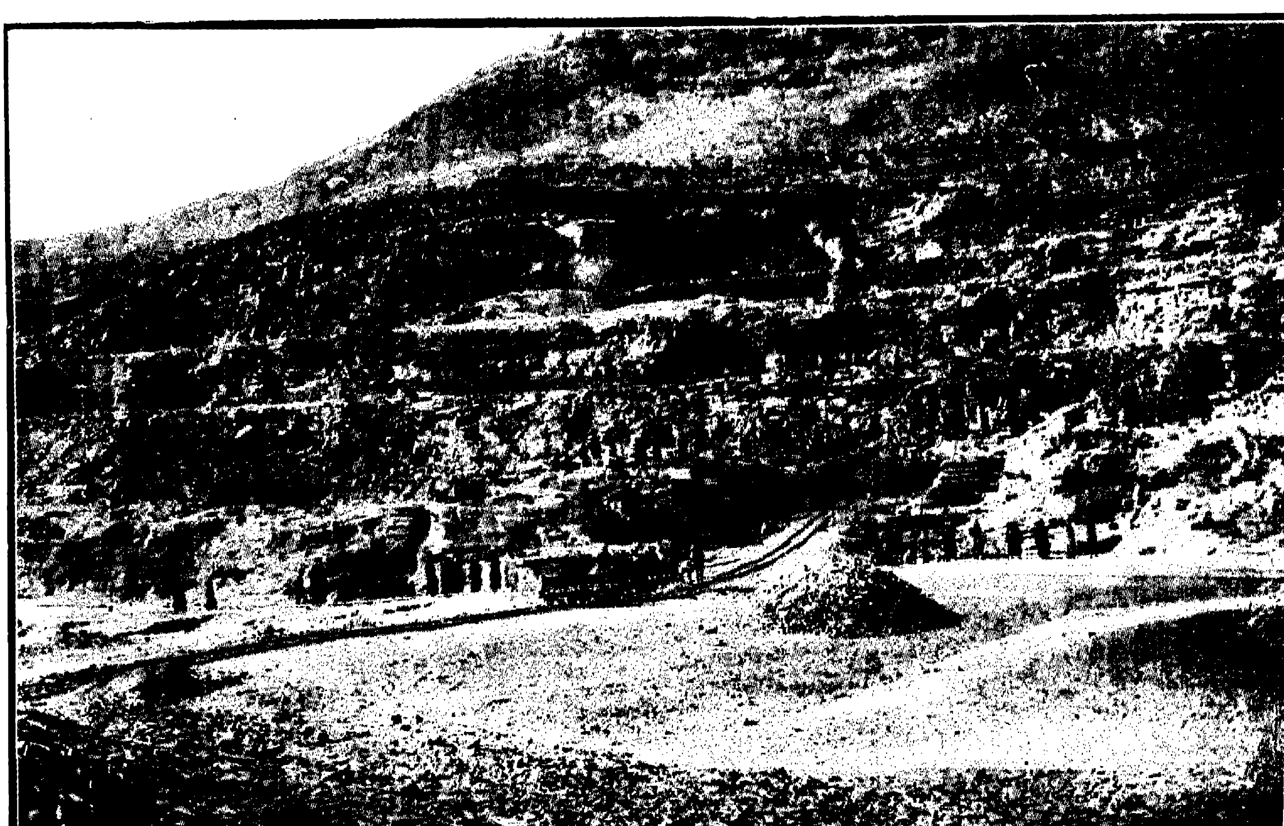


FIG. 1. DAM ACROSS THE MEJ RIVER AT SHEKAODA.



Messrs. Killick Nixon & Co., Photos. *G. S. I. Calcutta.*

FIG. 2. GENERAL VIEW OF QUARRIES AT LAKHERI.

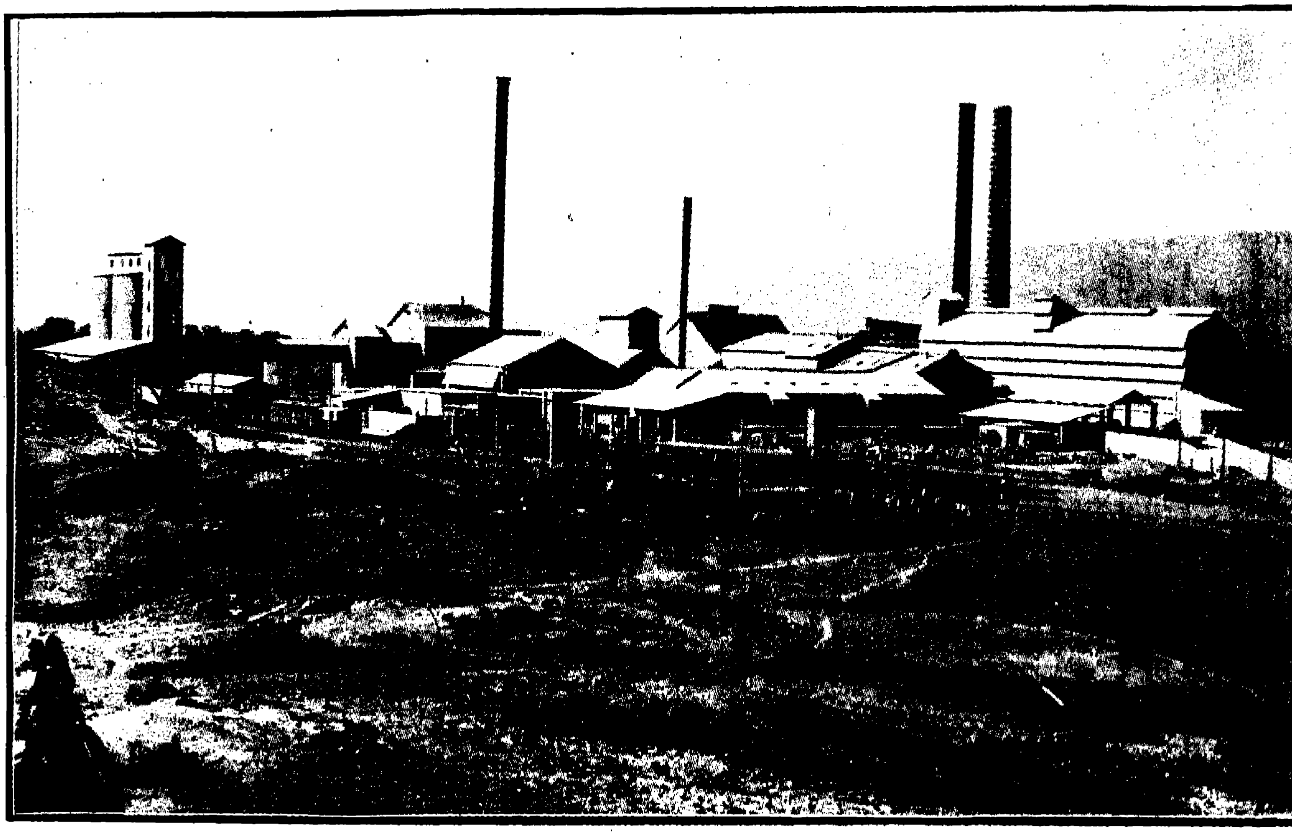


FIG. 1. THE BUNDI PORTLAND CEMENT WORKS, LAKHERI, (looking west).

Messrs. Killick Nixon & Co., Photos. *G. S. I. Calcutta.*

FIG. 2. ROTARY KILNS, BUNDI PORTLAND CEMENT WORKS, LAKHERI.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3] 1927 [Vol. LX.

THE MINERAL PRODUCTION OF INDIA DURING 1926. BY

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CONTENTS.

I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these Records (Vol. XXXII, 1905), although admittedly not entirely satisfactory, is still the best that

can be devised under present conditions. As the methods of collecting the returns become more precise and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods, and thus forming the basis of an industry carried on by a large number of persons, each working independently and on a very small scale, the collection of reliable statistics is impossible; the total error from year to year is, however, not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

The average value of the Indian rupee during the year 1926 was 1*s*. $5\frac{15}{16}$*d.*; the highest value reached was 1*s*. $6\frac{5}{32}$*d.*, and the lowest 1*s*. $5\frac{3}{4}$*d*. The values shown in Table 1 and all following tables of the present Review are given on the basis of 1*s*. $6\frac{1}{32}$*d.* to the rupee for 1925 and 1*s*. $5\frac{15}{16}$*d.* to the rupee for 1926, the latter ratio being taken for ease of calculation as equivalent to Rs. 13·4 to £1, instead of Rs. 13·379.

From Table 1 it will be seen that there has been an apparent decrease of nearly £1,697,000 or about 6·2 per cent. in the value of the total production over that of 1925. This decrease is minimised by a slight increase in the average exchange value of the rupee. An increase or decrease in value does not always correspond to a similar variation in output, and cannot, therefore, be regarded as an infallible indication of the state of an industry. It must be understood that the figures of Table 1 are value figures and that a decrease does not necessarily mean a reduced output or a decline in the industry. For instance, in the cases of coal, manganese, silver and magnesite, production increased and the reduced value figures are due to a drop in the market price.

The number of mineral concessions granted during the year amounted to 758 against 859 in the preceding year; of these one was an exploring license, 4 were quarry leases, 616 were prospecting licenses and 137 were mining leases.

TABLE 1.—*Total Value of Minerals for which returns of production are available for the years 1925 and 1926.*

	1925 (£1 = Rs. 13·3).	1926 (£1 = Rs. 13·4).	Increase.	Decrease,	Variation per cent.
Coal	9,503,828	7,574,599	..	1,929,229	—20·3
Petroleum	7,740,727	7,305,509	..	435,218	—5·8
Manganese (*a*)	2,617,220	2,590,357	..	26,863	—1·0
Lead and lead-ore	1,666,824	1,690,505	23,681	..	+1·4
Gold	1,673,501	1,624,236	..	49,265	—2·9
Building materials	853,851	860,558	6,707	..	+0·8
Salt	574,628	836,830	262,202	..	+45·6
Mica (*b*)	799,483	820,901	21,418	..	+2·7
Silver	705,503	663,063	..	42,440	—6·0
Tin and tin-ore	267,931	455,362	187,431	..	+69·9
Copper ore and matte	262,297	362,566	100,269	..	+38·2
Iron-ore	336,775	349,676	12,901	..	+3·8
Zinc-ore (*b*)	156,375	321,177	164,802	..	+105·4
Saltpetre (*b*)	147,617	98,846	..	48,771	—33·0
Tungsten-ore	33,975	57,535	23,560	..	+69·3
Jadeite (*b*)	12,237	35,091	22,854	..	+186·8
Ruby, Sapphire and Spinel.	27,454	34,834	7,380	..	+26·9
Clays	18,254	32,807	14,553	..	+79·7
Chromite	40,171	30,810	..	9,361	—23·3
Magnesite	31,179	26,444	..	4,735	—15·2
Steatite	(*c*) 15,119	11,213	..	3,906	—25·8
Ilmenite	492	7,587	7,095	..	—
Gypsum	5,810	5,704	..	106	—2·0
Alum	1,718	3,761	2,043	..	+118·9
Zircon	4,608	2,987	..	1,621	—39·5
Ochre	2,639	2,277	..	362	—13·7
Diamonds	1,098	2,131	1,033	..	+94·1
Bauxite	6,320	2,744	..	3,576	—56·3
Amber	710	1,599	889	..	+125·2
Fuller's earth	1,615	1,761	146	..	+9·2
Refractory materials	3,022	1,624	..	1,398	—46·2
Monazite	..	947	947	..	—
Apatite	850	804	..	46	5 4
Asbestos	361	786	425	..	+117·8
Barytes	1,328	690	..	638	—48·0
Corundum	..	342	342	..	—
Antimony	26	201	175	..	—
Soda	171	285	114	..	+66·6
Beryl	..	7	7	..	
Serpentine	8	3	..	5	—62·5
Copperas	1	2	1	..	+100·0
Borax	..	2	2	..	—
Oil Shale	15	..	..	15	
Total	**27,515,741**	**25,819,163**	**860,977**	**2,557,555**	**—6·2**
			$\underbrace{\qquad\qquad\qquad}_{\text{—1,696,578}}$		

(*a*) Value f. o. b.
(*b*) Export values.
(*c*) Revised.

II.—MINERALS OF GROUP I.

Chromite.	Iron.	Manganese.	Ruby, Sapphire and Spinel.	Silver.
Coal.	Jadeite.	Mica.	Salt.	Tin.
Copper.	Lead.	Monazite.	Saltpetre.	Tungsten.
Diamonds.	Magnesite.	Petroleum.		Zinc.
Gold.				

Chromite.

There was again a decrease in the production of chromite in India during 1926, amounting to 4,070 tons. For this decrease the Zhob valley and the Singhbhum deposits were responsible. The total exports from India during the year amounted to 39,951 tons and exceeded the production by 6,569 tons; the latter was evidently supplemented from stocks accumulated in previous years. Chromite exported from the ports in British India amounted to 29,614 tons against 36,157 tons in 1925. Chromite mined in British India is also exported from the port of Mormugao in Portuguese India; the quantities exported during 1925 and 1926 were 12,166 tons and 10,337 tons respectively.

TABLE 2.—*Quantity and value of Chromite produced in India during 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Baluchistan—						
Quetta-Pishin .	10	150	11	..	..	..
Zhob . .	18,188	2,65,121	19,934	14,832	2,17,715	16,247
Bihar and Orissa—						
Singhbhum .	3,038	69,274	5,208	1,623	37,028	2,763
Mysore State—						
Hassan . .	8,662	82,896	6,233	10,827	97,116	7,248
Kadur . .	1,900	15,200	1,143	..	..	..
Mysore . .	5,654	1,01,639	7,642	6,100	61,000	4,552
Total .	**37,452**	*5,34,280*	*40,171*	**33,382**	*4,12,859*	*30,810*

Coal.

There was a small increase during the year of 94,790 tons, or about 0·45 per cent., in the output of coal. This increase was due

chiefly to Bengal, partly to Bihar and Orissa, and to a small extent to Rajputana. The production in the Central Provinces and Hyderabad shewed a substantial decrease. There was a decline also in Assam and the production in Baluchistan was less than half what it was during the previous year. The increase in Bengal was from the Raniganj field, and in Bihar and Orissa mostly from the Karanpura, Giridih and Bokaro fields; Bokaro now produces over 7 per cent. of the Indian total. Giridih again increased her raisings, the increase amounting to some 32,000 tons, while Karanpura jumped from its initial production of 13,354 tons in 1925 to nearly 124,000 tons in the year under review. Jainti shewed an improvement and the output from Talchir again increased. The total increase in the production from Bengal, Bihar and Orissa was made in the face of a decline in the case of Jharia amounting to over 303,000 tons. In Central India, Sohagpur again failed to continue its former upward tendency and shewed a further decline of some 7,500 tons. In the Central Provinces there was a substantial decrease in the case of Pench Valley, and a smaller reduction in the case of Ballarpur. For the decrease in Hyderabad, Singareni was mainly responsible, but the Sasti output fell by nearly 10,000 tons. Amongst the Tertiary fields of Assam, the Naga Hills and Makum were responsible for a deficit. In Baluchistan the Khost field continued its decline and dwindled to some 3,500 tons. The output from the three districts of the Punjab declined, while the Bikanir field of Rajputana again shewed improvement.

The total value of the coal produced in India decreased from Rs. 12,64,00,908(£9,503,828) in 1925 to Rs. 10,14,99,634 (£7,574,599) in 1926.

There was a reduction in the pit's mouth value per ton of coal in all provinces (the figure for Burma is not available); this fall in value was severe in all cases except in Central India, where it amounted only to Re. 0-0-2. In the two great coal provinces, Bihar and Orissa and Bengal, the price dropped Rs. 1-1-9 and Rs. 1-8-11 respectively. In the Central Provinces it fell Rs. 0-15-0; in Assam the fall was Rs. 0-12-4, in the Punjab Rs. 0-14-8, and in Rajputana Rs. 0-11-5. The maximum fall, Rs. 3-9-4, was in Baluchistan, where, however, conditions are abnormal and coal supplies small. The fall in value is the more noticeable in view of the serious decline in the average figure for the previous year.

TABLE 3.—*Average Price (per ton) of Coal extracted from the Mines in each Province during the years 1925 and 1926.*

	1925.			1926.		
	Rs.	A.	P.	Rs.	A.	P.
Assam	8	10	1	7	13	9
Baluchistan	13	0	9	9	7	5
Bengal	6	12	6	5	3	7
Bihar and Orissa	5	11	3	4	9	6
Central India	4	9	3	4	9	1
Central Provinces	6	3	2	5	4	2
Punjab	8	3	5	7	4	9
Rajputana	6	15	2	6	3	9

TABLE 4.—*Provincial Production of Coal during the years 1925 and 1926.*

Province.	1925.	1926	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	318,842	301,061	..	17,781
Baluchistan	34,797	15,586	..	19,211
Bengal	4,913,852	5,137,688	223,836	..
Bihar and Orissa	13,938,509	13,955,775	17,266	..
Burma	25	..	..	25
Central India	219,106	216,708	..	2,398
Central Provinces	708,554	635,252	..	73,302
Hyderabad	667,877	637,779	..	30,098
Punjab	74,662	68,043	..	6,619
Rajputana	28,153	31,275	3,122	..
Total	**20,904,377**	**20,999,167**	**244,224**	**149,434**

TABLE 5.—*Origin of Indian Coal raised during 1925 and 1926.*

——	Average of last five years.	1925.	1926.
	Tons.	Tons.	Tons.
Gondwana Coalfields	19,545,203	20,447,898	20,583,202
Tertiary Coalfields	464,692	456,479	415,965
Total .	**20,009,895**	**20,904,377**	**20,999,167**

TABLE 6.—*Output of Gondwana Coalfields for the years 1925 and 1926.*

Coalfields.	1925.		1926.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
Bengal, Bihar and Orissa—				
Bokaro	1,494,966	7·15	1,514,918	7·21
Daltonganj	17,274	0·08	9,757	0·05
Giridih	786,642	3·76	818,681	3·90
Jainti	76,680	0·37	82,604	0·39
Jharia	10,676,883	51·08	10,373,736	49·40
Karanpura	13,354	0·07	123,867	0·59
Rajmahal Hills . . .	1,653	0·01	1,788	0·01
Ramgarh	2,548	0·01	585	0·00
Rampur (Raigarh-Hingir) .	45,410	0·22	29,272	0·14
Raniganj	5,729,686	27·42	6,124,884	29·17
Talchir	7,265	0·04	13,371	0·07
Central India—				
Sohagpur	116,170	0·55	108,599	0·52
Umaria	102,936	0·49	108,109	0·51
Central Provinces—				
Ballarpur	150,490	0·72	142,935	0·68
Mohpani	70,039	0·34	71,482	0·34
Pench Valley	485,768	2·30	416,708	1·98
Shahpur	1,119	0·01	423	0·00
Yeotmal	1,138	0·01	3,704	0·02
Hyderabad—				
Sasti	38,153	0·18	28,034	0·14
Singareni	629,724	3·01	609,745	2·90
Total .	**20,447,898**	**97·82**	**20,583,202**	**98·02**

TABLE 7.—*Output of Tertiary Coalfields for the years 1925 and 1926.*

	1925.		1926.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
Assam—				
Khasi and Jaintia Hills	845		555	
Makum	262,959	1·52	255,189	1·43
Naga Hills	55,038		45,317	
Baluchistan—				
Khost	17,085	0·17	3,545	0·07
Sor Rang, Kalat, Mach	17,712		12,041	
Burma—				
Southern Shan States	25	0·00	..	..
Punjab—				
Jhelum	49,369		46,961	
Mianwali	18,341	0·36	15,644	0·33
Shahpur	6,952		5,438	
Rajputana—				
Bikaner	28,153	0·13	31,275	0·15
Total	**456,479**	2·18	**415,965**	1·98

The export statistics for coal during 1926 shew an enormous increase amounting to some 399,000 tons, the total exports of coal and coke rising from 216,090 to 615,288 tons, 1,139 tons of the latter being coke (see Table 8). As before the exports were mainly to Ceylon.

TABLE 8.—*Exports of Indian Coal and Coke during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
To—	Tons.	Rs.	£	Tons.	Rs.	£
Aden and Dependencies .	..	..	..	59,342	7,42,971	55,446
Ceylon	194,189	28,65,560	215,456	242,685	33,19,630	247,733
Egypt	..	..	..	105,711	13,39,340	99,951
Straits Settlements (including Labuan).	18,754	3,18,818	23,971	117,246	15,15,873	113,125
United Kingdom . . .	2	37	3	49,088	5,28,546	39,444
Other Countries . . .	2,307	38,347	2,883	40,077	4,30,500	32,127
TOTAL .	215,252	32,22,762	242,313	614,149	78,76,860	587,826
Coke	838	21,329	1,604	1,139	33,636	2,510
Total of Coal and Coke .	*21[illegible],090*	*32,44,091*	*243,917*	61[illegible],288	*79,10,496*	*590,336*

This largely increased export figure is, however, still below that of some earlier years (*e.g.* 1,224,758 tons in 1920); but as it is mainly the result of the first year's operations of the Indian Coal Grading Board established for the purpose of certifying the quality of coal exported from the port of Calcutta, it must be taken as a favourable augury for the future prospects of this scheme for the rehabilitation of Indian coal in foreign markets. The following table shows the amounts of different grades of coal exported under this scheme (excluding sea-borne coal for railways in Southern India, for which no Grade Shipment Certificates were issued by the Coal Grading Board), the difference between the total amounts so exported (1,484,301 tons) and the total exports of Indian coal to foreign ports given in Table 8 (615,288 tons) being the amount of coal exported through Indian ports :

	Tons.
Selected Grade	943,821
Grade I	228,640
Grade II	28,135
Grade III	7,822
Mixed Grades	82,522
Under reference	193,361
TOTAL .	1,484,301

The imports at the same time dropped from 483,160 to 193,857 tons, 19,073 tons of the latter consisting of coke (see Table 9). A large proportion of the imports still come from South Africa though this figure is less than half what it was in the preceding year. The imports from Portuguese East Africa fell proportionally more than those from South Africa, and those from the United Kingdom still more, proportionally. As in 1924 Portuguese East Africa still ranks second in the list of countries supplying India with coal, while the United Kingdom still comes third.

TABLE 9.—*Imports of Coal and Coke during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
Australia . . .	7,495	2,34,485	17,630	13,323	3,79,656	28,333
Portuguese East Africa	130,312	29,36,146	220,763	46,044	9,58,465	71,527
Union of South Africa	183,582	42,22,505	317,481	84,956	18,03,105	134,560
United Kingdom .	111,898	29,65,309	222,956	21,374	5,74,089	42,842
Other Countries . .	17,053	3,97,402	29,880	9,087	1,72,360	12,863
TOTAL .	450,340	1,07,55,847	808,710	174,784	38,87,675	290,125
Coke	32,820	10,41,218	78,287	19,073	5,97,805	44,612
Total of Coal and Coke .	483,160	*1,17,97,065*	*886,997*	193,857	*44,85,480*	*334,737*

The average number of persons employed in the coalfields during the year shewed an appreciable decrease in spite of the small increase in production. The average output per person employed, therefore, showed an advance on the previous year, the figure of 110·5 tons for 1925 rising to 113·1 tons for 1926; this exceeds the figure for 1919 which was 111·05 tons. There was again a gratifying reduction in the number of deaths by accident; these amounted to 184, a considerable improvement on the annual average for the quinquennium 1919-23 which was 274, and not due to smaller production. There was also a reduction in the death-rate which again fell from 1·07 per thousand persons employed in 1925 to 0·99 for 1926; the figure for 1923 was 1·81.

TABLE 10.—*Average number of Persons employed daily in the Indian Coalfields during the years 1925 and 1926.*

	Number of persons employed daily.		Output per person employed, in tons.	Number of deaths by accidents.	Death-rate per 1,000 persons employed.
	1925.	1926.			
Assam	4,199	4,523	66·6	15	3·3
Baluchistan	951	232	67·2	..	..
Bengal	42,781	43,498	118·1	50	1·2
Bihar and Orissa	114,934	112,945	123·6	96	0·9
Burma	19	..	..	..	..
Central India	2,759	2,497	86·8	..	..
Central Provinces	9,174	8,366	75·9	10	1·2
Hyderabad	12,701	12,134	52·6	13	1·1
Punjab	1,579	1,388	49·0	..	..
Rajputana	165	166	188·4	..	..
Total	**189,262**	**185,749**	..	184	..
AVERAGE	..	..	113·1	..	0·99

Copper.

Work at the Mosaboni Mine of the Indian Copper Corporation Ltd., in the Singhbhum district, was practically suspended during the year 1926, pending the raising of the capital required for the erection of the necessary concentrating, smelting, refinery and power plants. A sum of £350,000 has now been subscribed for this purpose and the erection of the new plant has commenced.

Some 545,000 tons of ore have now been developed and are estimated to contain over 21,000 tons of copper, which represent a value substantially in excess of a million sterling. The quantity of copper ore produced in the driving of the necessary levels, winzes and shafts since the commencement of mining operations over the area amounted to 35,823 tons; of this 9,504 tons valued at Rs. 3,80,160 (£28,370) were hoisted during 1926.

A small output of 4 tons of copper ore valued at Rs. 160 (£12) was reported from the Nellore district of Madras.

The production of copper matte by the Burma Corporation, Ltd., in the Northern Shan States in Burma, rose from 8,029 tons valued at Rs. 34,88,552 (£262,297) in 1925 to 11,441 tons valued at Rs. 44,78,064 (£334,184) in the year under review.

Diamonds.

The production of diamonds in Central India rose from 47·63 carats valued at Rs. 14,598 (£1,098) in 1925 to 68·60 carats valued at Rs. 28,559 (£2,131) in the year under review.

Gold.

It was stated in the previous review that both the Jubital Gold Mines, Ltd., and the North Anantapur Gold Mines, Ltd., had suspended mining operations. The latter Company, however, obtained a fresh mining lease over an area of 1,604 acres in the Anantapur district in the Madras Presidency and produced 930 oz. of gold in 1926.

Production of gold has not been reported from the Singhbhum district since the year 1920. In the year under review 123 oz. of gold were produced from Mr. E. F. O. Murray's Kondarkocha Mine.

Including a decline of 10,613·5 oz. from the Kolar mines of Mysore, therefore, there was a total decrease in the Indian output amounting to 9,716·6 oz.

Champion and Ooregum, the deepest mines on the Kolar Gold Field, reached depths of 6,556 feet and 6,392 feet, respectively, below the field datum on the 31st December 1926. There has been a slight drop in the estimated ore reserves mainly due to restricted development operations but the deepest points so far reached indicate that further exploration will probably permit an increased estimate. Rock-bursts still continue to give trouble but steps are being taken to minimise their effect by adopting improved methods of supporting ground and close filling of the stoped-out areas with waste rock. The lining of shafts in concrete—both vertical and incline—to reduce the risk of damage by rock-bursts or mine fires, is being tried largely in the Champion Reef Mine and to a less extent in the Ooregum Mine. Such concrete or brick-lined shafts, generally

oval or circular in shape, are coming into general use on this field; they are decidedly cleaner than timbered shafts and promote better ventilation since there is less friction.

TABLE 11.—*Quantity and value of Gold produced in India during the years 1925 and 1926.*

	1925.			1926.			
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).		Labour.
	Oz.	Rs.	£	Oz.	Rs.	£	
Bihar and Orissa—Singhbhum .	..	..	..	123·0	6,600	493	23
Burma—Katha . .	19·7	1,265	95	24·2	1,491	111	4
Upper Chindwin.	13·4	1,286	97	122·4	11,127	830	115
Kashmir .	..	..	..	46·7	1,995	149	145
Madras—Anantapur .	(*a*) 288·0	16,517	1,242	(*a*) 930·0	53,219	3,972	308
Mysore . .	(*a*) 393,512·8	2,22,36,295	1,671,901	(*a*) 382,899·3	2,16,89,632	1,618,629	18,742
Punjab . .	37·4	1,974	149	8·8	444	33	41
United Provinces.	3·8	225	17	4·1	250	19	14
Total .	393,875·1	*2,22,57,562*	*1,673,501*	384,158·5	*2,17,64,758*	*1,624,236*	19,392

(*a*) Fine gold.

Iron.

The production of iron ore in India has been steadily on the increase; in 1926 there was an increase over the previous year of 7·4 per cent., amounting to 114,148 tons. The figure shown against the Mayurbhanj State in Table 12 represents the production by the Tata Iron & Steel Company, Ltd., whilst of that recorded against Singhbhum, 165,068 tons were produced by the Indian Iron and Steel Company, Ltd., from their mines at Gua, 228,261 tons by the Bengal Iron Company, Ltd., from their Pansira, Ajita and Maclellan Mines and 156,425 tons by the Tata Iron & Steel Company, Ltd., from their Noamundi Mine; the remaining 2,325 tons were produced by two other firms. The output of iron ore

in Burma is by the Burma Corporation, Limited, and is used as a flux in lead smelting.

TABLE 12.—*Quantity and value of Iron-ore produced in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa— Mayurbhanj	957,275	28,71,825	215,927	1,041,929	31,25,787	233,267
Sambalpur	703	4,920	370	569	3,930	293
Singhbhum	477,580	12,36,840	92,996	552,079	12,84,922	95,890
Burma— Mandalay	1,013	(a) 4,052	305	..	..	..
Northern Shan States	50,604	(a) 2,02,416	15,219	48,089	(a) 1,92,356	14,355
Central Provinces	1,037	4,182	314	972	3,987	298
Mysore	56,218	1,54,000	11,579	(b) 15,427	73,278	5,468
Other Provinces and States	148	866	65	230	1,406	105
Total	1,544,578	*44,79,101*	*336,775*	1,659,295	*46,85,666*	*349,676*

(*a*) Estimated.
(*b*) Excludes 1,909 tons of hæmatite quartzite.

Consequent on the increased production of iron ore by the Tata Iron and Steel Company, Ltd., there was a corresponding increase in the output of refined products at the Jamshedpur works; the production of pig iron rose from 563,160 tons in 1925 to 609,429 tons in 1926 and of steel (including steel rails) from 309,938 tons in 1925 to 360,980 tons in 1926; the production of ferro-manganese also rose from 6,527 tons in 1925 to 10,503 tons in 1926. The production of pig iron by the Bengal Iron Company, Ltd., fell considerably from 52,674 tons in 1925 to 20,050 tons in 1926; their output of iron castings and sleepers, including chairs and pipes, increased however from 5,911 tons and 29,327 tons in 1925 to 9,196 tons and 61,622 tons, respectively, in 1926. There was a further increase in the production of pig iron by the Indian Iron and Steel Company, Ltd., from 247,500 tons in 1925 to 253,431 tons in 1926.

The Mysore Iron Works commenced producing pig iron in 1923 when the quantity manufactured amounted to 9,732 tons; although the production of iron ore in 1926 was less than one-third of that in the previous year, the output of pig iron rose from 16,741 tons in 1925 to 19,523 tons in the year under review.

The number of indigenous furnaces that were at work in the Central Provinces during the year 1926 for the purpose of smelting iron ore remained the same as in the previous year; 102 furnaces were operating in the Bilaspur district, 68 in Raipur, 36 in Mandla, 4 in Saugor and 1 in Jubbulpore, making 211 in all.

There was a further increase in the production of pig iron in India from 880,075 tons in 1925 to 902,433 tons in 1926, but the quantity exported fell from 381,989 tons in 1925-26 to 309,505 tons in 1926-27. Table 13 will show that Japan was the principal consumer of Indian pig iron in 1926-27, more than 75 per cent. of the total exports going to that country. There was a very slight fall in the export value which was Rs. 45·9 (£3·45) per ton in 1925-26 and Rs. 45·1 (£3·37) per ton in the following year.

TABLE 13.—*Exports of Pig-iron from India during 1925-26 and 1926-27.*

	1925-26.			1926-27.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom .	20,178	9,33,916	70,219	16,159	7,29,617	54,449
Germany . . .	11,288	5,24,509	39,437	2,868	1,29,086	9,633
China (including Hong-kong).	11,214	5,11,684	38,472	7,616	3,31,296	24,724
Japan . . .	168,188	76,57,025	575,716	234,529	1,05,71,787	788,939
United States of America	156,064	72,18,036	542,709	40,733	18,33,744	136,847
Other Countries . .	15,057	7,05,034	53,011	7,600	3,67,753	27,444
Total .	**381,989**	*1,75,50,204*	*1,319,564*	**309,505**	*1,39,63,283*	*1,042,036*

The Steel Industry (Protection) Act, 1924—Act No. XIV of 1924—authorised, to companies employing Indians, bounties, which were

granted upon rails and fishplates wholly manufactured in British India from material wholly or mainly produced from Indian iron ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons a substantial portion of the component parts of which had been manufactured in British India. This Act was repealed by the Act No. III of 1927 and consequently the payment of bounties ceased on the 31st March 1927, but the Industry is protected to a certain extent by varying tariffs on different classes of imported steel.

Jadeite.

The fall in the output of Jadeite which commenced after the year 1922 has persisted, and the output, which in 1925 amounted to 1,696·5 cwts. valued at Rs. 2,67,148 (£20,086), decreased to 1,203·9 cwts. valued at Rs. 2,34,456 (£17,497) in 1926. The output figures are always incomplete and a more correct idea of the extent of the Burmese Jadeite industry is usually obtainable from the export figures. Exports by sea rose from 972 cwts. valued at Rs. 1,62,751 (£12,237) in 1925-26 to 2,139 cwts. valued at Rs. 4,70,225 (£35,091) in 1926-27. The shipments were made entirely from Burma. These figures exclude exports by land across the frontier to foreign countries as the registration of the Land Frontier Trade of Burma has been discontinued.

Lead.

Corresponding to an increase in the production of lead ore at the Bawdwin Mines of Burma the total amount of metal extracted increased from 47,275 tons of lead including 1,100 tons of antimonial lead, valued at Rs. 2,21,07,128 (£1,662,190) in 1925 to 54,330 tons of lead including 1,057 tons of antimonial lead, valued at Rs. 2,25,94,634 (£1,686,167) in 1926. The quantity of silver extracted from Bawdwin ores also increased from 4,831,548 oz. valued at Rs. 93,36,580 (£701,998) in 1925 to 5,103,646 oz. valued at Rs. 88,49,722 (£660,427) in 1926. The value of both lead and silver fell respectively from Rs. 468 (£35·2) per ton and Rs. 1-14-11 (34·9*d.*) per oz. in 1925 to Rs. 416 (£31) per ton and Rs. 1-11-9 (31·06*d.*) per oz. in the year under review.

TABLE 14.—*Production of Lead and Silver ore during the years 1925 and 1926.*

—	1925.					1926.				
	Quantity.	Value (£1 = Rs. 13·3).				Quantity.	Value (£1 = Rs. 13·4).			
	Lead-ore.	Lead-ore and Lead.		Silver.		Lead-ore.	Lead-ore and Lead.		Silver.	
	Tons.	Rs.	£	Rs.	£	Tons.	Rs.	£	Rs.	£
Burma—										
Northern Shan States	321,389	(a) 2,21,07,128	1,662,190	(b) 93,36,580	701,998	362,505	(c) 2,25,94,634	1,686,167	(d) 88,49,722	660,427
Southern Shan States	445	59,525	4,476	..	..	375	55,995	4,179	..	..
Yamethin	20	800	60	..	..	24	960	72	..	..
Rajputana—										
Jaipur State	7	1,300	98	..	..	6·6	1,170	87	..	..
Total	321,861	*2,21,68,753*	*1,666,824*	*93,36,580*	*701,998*	362,910·6	*2,26,52,759*	*1,690,505*	*88,49,722*	*660,427*

(*a*) Value of 46,175 tons of lead (Rs. 2,18,23,219) and 1,100 tons of antimonial lead (Rs. 2,83,909) extracted.
(*b*) Value of 4,831,548 oz. of silver extracted.
(*c*) Value of 53,273 tons of lead (Rs. 2,22,74,134) and 1,057 tons of antimonial lead (Rs. 3,20,500) extracted.
(*d*) Value of 5,103,646 oz. of silver extracted.

Magnesite.

The magnesite industry in the Salem district of Madras, which revived in 1921, continues to flourish, although there was a slight decrease in the production from 29,620 tons valued at Rs. 4,14,680 (£31,179) in 1925 to 28,676 tons valued at Rs. 3,41,925 (£25,517) in 1926. The mines in Mysore which were not worked in 1925 yielded an output of 1,785 tons valued at Rs. 12,430 (£927) in 1926. The total Indian production amounting to 30,461 tons in the year under review exceeded that of the preceding year by 841 tons and is the highest yet recorded.

TABLE 15.—*Quantity and value of Magnesite produced in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Madras—						
Salem	29,620	4,14,680	31,179	28,676	3,41,925	25,517
Mysore State	..	..	..	1,785	12,430	927
Total	29,620	*4,14,680*	*31,179*	30,461	*3,54,355*	*26,444*

Manganese.

A rise in the output of manganese ore in India is again to be recorded, the total for 1925, 839,461 tons valued at £2,617,220 f. o. b. Indian ports, rising to 1,014,928 tons valued at £2,590,357 f. o. b. Indian ports, during the year under consideration. The figure for output is the highest yet recorded and exceeds that for 1907 when 902,291 tons were raised. It will be noticed that concurrent with a rise in output there was, as in the previous year, a fall in value, the total value for 1926 being £26,863 less than that for 1925. This was again due to a fall in price. In 1924 first grade ore c. i. f. United Kingdom ports fetched an average price of 22·9*d.* per unit; in 1925 this price fell to 21·5*d.* and in 1926 to 18*d.* A fall in price was anticipated in view of the agreement, two or three years ago, between an American group of financiers and the Soviet

Government for the development on modern lines of the manganese ores of the Caucasus; for political or economic reasons not yet fully understood no development has yet been carried out, and the precise position is obscure. In addition to the four chief manganese-producing areas, India, Brazil, the Gold Coast and Cuba, a further source at Postmasburg in the northern part of the Cape Province is promising; the grade is high and the deposits extensive, the only drawback being the presence of aluminous compounds.

In the case of the output from Bihar and Orissa the increases in Gangpur and Singhbhum were balanced by a decrease in Keonjhar and Sambalpur. In the Bombay Presidency the Panch Mahals again shew a substantial increase and Chhota Udaipur shews a recovery to its position in 1924; the production from Belgaum shews an increase of 686 tons. A production is for the first time recorded from North Kanara. After a break of several years Jhabua State in Central India had resumed production in 1924; it shews a second substantial increase amounting to 4,763 tons in the year under review. The most important Indian manganese areas, *viz.*, those of the Central Provinces, exhibited an increase of over 38,000 tons in 1925, but this is eclipsed by an increase of over 139,000 tons in the year under consideration, all provinces except that of Jubbulpore participating. In Madras, Bellary increased its small output while a large increase in the Sandur State output amply covered a deficit in Vizagapatam. Mysore again shews a fall in output due to the Shimoga and Chitaldrug districts.

The exports of manganese ore, which during 1924 fell to the extent of about 100,000 tons, decreased in 1925 by about 27,600 tons and again in 1926 by 125,300 tons as shewn in Table 17. There is a steady consumption of manganese ore at the works of the three principal Indian iron and steel companies, not only for use in the steel furnaces of the Tata Iron and Steel Company, and the manufacture of ferro-manganese, but also for addition to the blast-furnace charge in the manufacture of pig-iron. The consumption of manganese-ore in the industry was 40,111 tons, 5,268 tons more than it was in the previous year.

Table 18 shews the distribution of the manganese ore exported from British Indian ports (excluding the Portuguese port of Mormugao) during 1925 and 1926, from which it will be seen that the amount absorbed by the United Kingdom in 1926 dropped to less than half of what it was in 1925. The quantity exported to Belgium

TABLE 16.—*Quantity and value of Manganese-ore produced in India during the years 1925 and 1926.*

—	1925.		1926.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons	£	Tons.	£
Bihar and Orissa—				
Gangpur State . .	9,617	30,334	10,379	26,856
Keonjhar State . .	26,330	66,264	23,810	47,322
Sambalpur . . .	703	2,217	..	..
Singhbhum . . .	195	615	2,473	6,399
Bombay—				
Chhota Udaipur . .	6,805	21,166	10,000	25,500
Belgaum . . .	3,604	11,368	4,290	10,100
North Kanara . .	..	..	2,000	5,175
Panch Mahals . .	52,069	164,234	57,325	148,328
Central India—				
Jhabua State . .	3,206	8,576	7,969	16,901
Central Provinces—				
Balaghat	262,450	873,740	336,579	921,385
Bhandara	104,398	347,558	152,858	418,449
Chhindwara . . .	37,109	123,542	42,242	115,637
Jubbulpore	1,901	6,329	100	274
Nagpur	216,484	720,711	229,586	628,492
Madras—				
Bellary	5,419	11,064	8,853	14,054
Kurnool	6	13	..	..
Sandur State . . .	52,576	107,343	77,327	122,757
Vizagapatam . . .	26,909	59,200	21,698	37,339
Mysore State—				
Chitaldrug	2,494	5,289	1,599	2,645
Shimoga	24,572	52,113	23,032	38,099
Tumkur	2,614	5,544	2,808	4,645
Total .	**839,461**	*2,617,220*	**1,014,928**	*2,590,357*

increased by 11,600 tons and this country now heads the list as chief importer. France maintained her previous figure while the decline in the case of Germany and Italy was amply balanced by increases on the part of the United States, the Netherlands and other countries.

TABLE 17.—*Exports of Manganese-ore during 1925 and 1926 according to Ports of Shipment.*

Port.	1925.	1926.
	Tons.	Tons.
Bombay	311,825	222,371
Calcutta	264,170	291,745
Madras	28,203	9,800
Mormugao (Portuguese India) . . .	134,653	89,620
Total .	**738,851**	**613,536**

TABLE 18.—*Exports of Manganese-ore from British Indian Ports during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons	Rs.	£
To						
United Kingdom .	180,472	45,09,085	339,029	74,750	20,80,509	155,262
Germany . . .	30,258	7,90,650	59,447	6,346	1,48,800	11,104
Netherlands . .	1,510	60,187	4,525	14,800	4,25,125	31,726
Belgium . . .	174,334	47,47,421	356,949	185,974	51,25,666	382,512
France . . .	151,585	37,02,370	278,374	151,906	42,60,342	317,936
Italy . . .	16,875	8,36,808	62,918	9,600	4,00,398	29,880
United States of America.	49,164	13,85,750	104,192	67,250	20,1[illegible],500	150,411
Other countries .	..	..	..	13,290	3,06,854	22,900
Total .	**604,198**	***1,60,32,271***	***1,205,434***	**523,916**	***1,47,63,194***	***1,101,731***

Mica.

There was a decrease in the declared production of mica from 45,990 cwt. valued at Rs. 21,99,516 (£165,377) in 1925 to 41,924 cwt. valued at Rs. 22,19,367 (£165,624) in 1926. As has been frequently pointed out, the output figures are incomplete, and a more accurate idea of the size of the industry is to be obtained from the export figures. It will be seen from Table 20 that in both the years 1925 and 1926 the quantity exported was more than double the reported production. The United States of America and the United Kingdom are the principal importers of Indian mica, which absorbed 52 per cent. and 35 per cent. respectively of the total quantity exported during the year under review. The average price of the mica exported rose from Rs. 107 (£8·0) per cwt. in 1925 to Rs. 122 (£9·1) per cwt. in 1926.

TABLE 19.—*Quantity and value of Mica produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bengal—						
Bankura	..	..	..	4	233	17
Bihar and Orissa—						
Gaya	3,631	1,80,811	13,595	1,782	1,21,855	9,094
Hazaribagh	25,606	12,67,390	95,292	26,789	13,46,376	100,476
Monghyr	973	37,675	2,833	743	39,808	2,971
Sambalpur	..	..	..	11	500	37
Gwalior	120	3,303	248	320	10,548	787
Madras—						
Nellore	14,378	5,91,390	44,465	11,271	5,98,532	44,667
Nilgiris	401	54,614	4,106	313	45,152	3,369
Mysore State—						
Hassan	48·5	2,690	202	..	..	..
Mysore	114·7	7,390	556	..	..	..
Rajputana—						
Ajmer-Merwara	401·7	40,920	3,077	538	46,863	3,497
Shahpura	316·4	13,333	1,003	153	9,500	709
Total	45,990·3	*21,99,516*	*165,377*	41,924	*22,19,367*	*165,624*

TABLE 20.—*Quantity and value of Mica exported from India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
To	Cwts.	Rs.	£	Cwts.	Rs.	£
United Kingdom .	36,118	50,01,385	376,044	31,618	44,13,886	329,394
Germany . . .	16,395	11,43,975	86,013	4,984	3,97,105	29,635
France . . .	1,186	2,14,049	16,094	1,340	2,69,630	20,122
United States of America.	39,928	35,40,048	266,169	47,038	51,94,255	387,631
Other countries .	6,072	7,33,666	55,163	4,967	7,25,201	54,119
Total .	99,6[illegible]9	*1,06,33,123*	*799,483*	89,947	*1,10,00,077*	*820,901*

Monazite.

The monazite industry of Travancore which almost died in the year 1925, when the reported production was 1 cwt. only, shewed signs of revival in the year under review, the output amounting to 64·2 tons valued at £947. The decline of the industry is of course due to the supplanting of incandescent mantles for gas lighting by electricity. It is hoped that the ilmenite collected with the monazite and hitherto regarded as it were as a by-product may be the means of reviving the whole industry. Titania forms a valuable white paint superior to white lead in being non-poisonous and in possessing twice the covering power.

Petroleum.

The figure published last year as the world production of petroleum in 1925—over 151¼ million tons—proved to be an over-estimate, the revised figure working out at 147,476,261 tons. The estimate for 1926 is thought to approximate to 150 million tons ; of this India contributed not quite 0·8 per cent. India is now ninth on the list of petroleum-producing countries, but is being rapidly overtaken by the Argentine. One of the features of the year was the advent of the new prolific sands of the Seminole field of Oklahoma. This, combined with an enormous expansion in the amount of light

petroleum distillates obtained by cracking and from casing-head sources, was the cause of an almost unprecedented over-production in the United States and a consequent fall in the world's price levels. As remarked before petroleum statistics prove that it is becoming more and more difficult to maintain the output of India (including Burma) at the high levels it reached in 1919 and 1921, when peak productions of well over 305½ million gallons were reached. During the year under consideration the total production amounted to less than 280½ million gallons against a little over 289½ million gallons in 1925. There is now little doubt that this repeated deficit, small as it is, forms part of the evidence that the inevitable decline has set in, and, with possible interruptions, is likely to continue slowly and steadily during the present generation, unless a new field of importance is discovered. The chances of the latter recede year by year as exhaustive geological research continues to prove fruitless. A conservative policy rather than one of intensive development seems indicated, especially in view of the national importance of this mineral asset. The value figure dropped slightly more than the production figure.

As before the Yenangyaung field of Upper Burma is mainly responsible for the present decrease in output. In 1924 it succeeded in shewing an increase of nearly 6½ million gallons but this temporary arrest in the decline was more than balanced by the drop in 1925 of over 21½ million gallons; in 1926 the drop amounted to over 14¼ million gallons. The decline in 1926 is partly attributable to a strike which took place during the first quarter of the year, and also it is thought, to heavy late rain: several wells were put out of action by land-slides and the Aungban Yo bridge was overthrown. It is interesting to note that the production in Yenangyaung still includes oil derived from the old Burmese hand-dug wells.

It is now seldom that a new well strikes a yield of over 100 barrels per initial twenty-four hours. The utilization of the shallow oil-sands of this field, which were shut off during the competitive rush for the richer deep sands, continues; many remunerative wells are now being worked from two shallow zones, one at about 350 feet and the other at about 650 feet, but in spite of the fact that the fall in the yield of the wells is unexpectedly gradual, the effect in delaying the decline of the field may be looked upon as almost negligible. The average daily yield of these shallow wells is about 2

barrels. The electrification of the field, which reached its limit of practicability in 1924, has added and is adding an appreciable contribution to the production figure, owing to the saving of a considerable quantity of crude oil formerly used as fuel beneath rig boilers.

Of the ten companies operating in this small field the Burmah Oil Company produce about four-fifths of the total output. Of undrilled portions of the Yenangyaung field the northern areas are shewing more promise than the southern. There is now good reason to believe that as the depth increases the crest of the anticline recedes more and more to the east; this means that the producing limits of oil pools will be found further and further eastwards as greater depths are attained. Deep test wells are to be put down to prove this. On this flank of the anticline an advance of "edge" water has shewn itself up one of the oil-sands. During the year there were 54 outbreaks of fire, from which no serious loss or damage to life or property resulted; 33 of these fires occurred during the strike and were due to incendiarism. Out of 65 accidents reported during 1926, 10 were fatal.

The place of Yenangyaung is being steadily taken by the Singu field, which in a few years will undoubtedly usurp the premier position so far held by the older field. Singu, the greater part of which is in the hands of the Burmah Oil Co., is used to make good the deficiencies of Yenangyaung, in order to maintain supplies to the refinery. In 1926, however, Singu produced only 483,000 gallons more than it did in 1925, and did not compensate the decrease in the older field. Many wells are producing from the 3,000-foot sand and initial yields of 500 barrels and over are not uncommon. The electrification of the Singu field is now being considered.

The Yenangyat field has now reduced itself to the status of the Upper Chindwin field and is outclassed by Minbu. Some deep tests are now being sunk in this field in the hope of reviving production. A scheme is under consideration by which the sandbank stretching southwards from the wells at Lanywa into the river Irrawaddy is to be protected by a revetted embankment. This, it is hoped, will enable a number of wells to be drilled by the Indo-Burma Petroleum Company on the sand-bank. As remarked in the Review of Mineral Production for 1920[1] the striking of remunerative sup-

[1] *Rec. Geol. Surv. Ind.*, Vol. LIII, p. 117.

plies of oil at Lanywa makes it almost certain that the river Irrawaddy covers oil deposits of commercial size. The sand-bank which stretches from Lanywa to Sitpin is a more or less permanent feature, dry during the winter but covered by the floods of the rainy season. Large artificial mounds will probably have to be built to carry the derricks. Strictly speaking, the area belongs to the Singu dome area, but officially it will be looked upon as part of the Yenangyat field.

Drilling operations, commenced in 1924 by the Indo-Burma Petroleum Company in the Pyaye anticline, some seven miles S. W. of Thayetmyo, have so far encountered nothing but gas and water. One well at a depth of 2,000 feet liberated gas in quantities estimated at 39 million cubic feet per 24 hours; the noise produced by its escape could be heard in Thayetmyo. With great difficulty and after five months of open flowing, the well was got under control. As this gas-well is thermally equivalent to an oil-well of something like 5,000 barrels a day, the possibility of a useful gas-field at Pyaye is worth serious consideration.

Of the other Burma fields, Thayetmyo again shews a decline as also does the Upper Chindwin. The production from Minbu increased by 1,285,000 gallons while the Arakan fields maintained their usual small output.

In Assam prospects are a little brighter. The Badarpur field, which had proved to be somewhat below expectations, decreased its output by over 1 million gallons; further efforts in Lower Assam have raised hopes of an extension in development. The Digboi field in Upper Assam again shewed a marked increase amounting to nearly 6½ million gallons; careful geological investigations by the Assam Oil Company's staff arouse expectations of a successful expansion of this field and an extension of the refinery is contemplated. So far negative results only have rewarded this company's scattered tests at Dhekiajuli, Dilli and Burragolai.

In the Punjab there is less cause for satisfaction. The output from the Khaur field has again dropped this time to the extent of over 1,800,000 gallons. A boring put down by the Whitehall Petroleum Corporation near Jhatla and 8 miles south-west of Talagang reached the great depth of 6,007 feet, without, unfortunately, striking oil in remunerative quantity. Traces only of oil were encountered and the most interesting point in connection with the well is the fact that it is considered to have pierced the entire

local sequence of Chinji, Kamlial and Murree beds and to have entered the Nummulitic below. As the beds are practically horizontal we have, therefore, a very carefully measured section of these groups. Assuming that the boundaries of these groups were correctly identified from the "drillings" and core (the lowest 1,606 feet were negotiated with a Sullivan diamond drill), the thickness of the Chinji stage is here 2,807 feet and that of the Kamlial stage and the Murree series combined 2,011 feet.

There was a slight fall in the imports of kerosene. Those from the United States were some 12 million gallons more than they were in 1925, but the decrease in oil obtained from Borneo and the cessation of supplies from Georgia, together balance this increase.

The quantity of fuel oil imported into India during 1926 was, as Table 23 will shew, some 8 million gallons more than that received during the previous year; the increase came from Borneo. Nearly three-quarters of the supply was derived from Persia, and the greater part of the rest from Borneo.

The export of paraffin wax increased to the extent of 9,130 tons during 1926 (*see* Table 24).

TABLE 21.—*Quantity and value of Petroleum produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur	4,281,878	11,17,012	83,986	3,210,838	6,77,068	50,527
Digboi	14,448,534	24,68,291	185,586	20,887,697	35,68,314	266,292
Burma—						
Akyab	7,169	2,483	187	6,331	2,191	164
Kyaukpyu	14,361	15,111	1,136	15,103	15,946	1,190
Minbu	3,248,566	9,13,659	68,696	4,533,420	10,15,297	75,769
Singu	95,262,519	3,57,23,445	2,685,973	95,745,504	3,59,04,564	2,679,445
Thayetmyo	1,320,009	3,71,253	27,914	974,620	2,18,274	16,289
Upper Chindwin	1,385,977	1,03,948	7,816	1,255,840	94,188	7,029
Yenangyat	1,562,444	4,39,437	33,040	1,778,041	3,39,865	25,363
Yenangyaung	160,027,885	5,97,85,227	4,495,130	145,781,612	5,45,00,540	4,067,204
Punjab—						
Attock	8,047,200	20,11,800	151,263	6,230,320	15,57,580	116,237
Total	289,606,542	*10,29,51,666*	*7,740,727*	280,369,326	*9,78,93,827*	*7,305,509*

TABLE 22.—*Imports of Kerosene Oil into India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
From—	Gals.	Rs.	£	Gals.	Rs.	£
Borneo .	14,867,813	78,89,050	593,161	6,291,079	36,66,380	273,611
Georgia .	4,310,642	24,26,941	182,477	..	..	..
Straits Settlements (including Labuan).	2,333,803	16,32,683	122,758	3,726,437	22,27,811	166,254
Sumatra .	1,148,962	7,35,087	55,270	915,971	6,37,814	47,598
United States of America.	45,889,437	3,17,36,254	2,386,184	57,962,329	3,93,34,516	2,935,412
Other countries	2,198,407	17,04,787	128,180	51,820	46,401	3,463
Total .	70,749,064	*4,61,24,802*	*3,468,030*	68,947,636	*4,59,12,931*	*3,426,338*

TABLE 23.—*Imports of Fuel Oils into India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
From—	Gals.	Rs.	£	Gals.	Rs.	£
Persia . .	69,701,096	1,38,98,930	1,045,032	69,344,118	1,40,50,401	1,048,537
Straits Settlements (including Labuan).	2,243,702	6,94,045	52,184	1,525,957	4,27,245	31,884
Borneo . .	14,599,813	48,39,013	363,836	23,597,902	61,30,911	457,531
Other countries	55,155	13,840	1,040	125,001	23,095	1,724
Total .	86,599,[illegible]66	*1,94,45,828*	*1,462,092*	94,592,978	*2,06,31,652*	*1,539,676*

TABLE 24.—*Exports of Paraffin Wax from India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
To— United Kingdom .	12,262	55,80,520	419,588	16,147	76,40,615	570,195
Belgium . . .	3,135	14,26,385	107,247	4,810	21,88,550	163,325
China . . .	3,369	17,51,645	131,703	2,942	15,89,289	118,604
Japan . . .	315	1,43,525	10,791	20	11,375	849
Union of South Africa .	2,019	9,18,531	69,062	3,074	13,98,695	104,380
Portuguese East Africa .	2,835	12,89,925	96,987	3,732	16,99,422	126,823
United States of America.	915	4,18,600	31,474	785	3,57,175	26,655
Australia and New Zealand.	1,625	8,21,474	61,765	1,368	6,23,131	46,502
Other countries . .	5,018	22,69,282	170,623	7,745	35,26,095	263,141
Total .	31,493	*1,46,19,887*	*1,099,240*	40,623	*1,90,34,347*	*1,420,474*

Ruby, Sapphire and Spinel.

A severe decline in the output from the Mogok ruby mines of Upper Burma in 1924, followed in 1925 by a marked drop in value, bore witness to a serious decline in the industry. The Burma Ruby Mines, Limited, ultimately decided to go into liquidation and the mines were offered for sale in September, 1926. The skeleton organisation left in charge of the mines has, however, made good use of its opportunities, with the result that the value of the output in 1926 exceeded that of the previous year by over a *lakh* of rupees. This encouraging result was effected by rigorous economy and an extension of a system of co-operation with local miners, and was assisted by some good finds of sapphires in the Kyaungdwin mine (the only one still worked by European methods).

TABLE 25.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma	109,998 (Rubies).	3,40,689	25,616	(a)	1,07,988 (Rubies).	8,059
	31,508 (Sapphires).	20,616	1,550	(a)	3,41,750 (Sapphires)	25,504
	7,531 (Spinels).	3,834	288	(a)	17,034 (Spinels).	1,271
Kashmir	..	..	..	252,120 (Sapphires).	(b)	..
Total	149,037	*3,65,139*	*27,454*	..	*4,66,772*	*34,834*

(a) Quantity not reported.
(b) Value figure not available.

Salt.

There was an increase in the total output of salt amounting to 343,605 tons, all provinces and States contributing thereto.

TABLE 26.—*Quantity and value of Salt produced in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden	188,493	9,10,370	68,450	194,524	9,35,531	69,815
Bombay and Sind	381,419	20,43,490	153,646	473,127	25,33,686	189,081
Burma	22,880	3,23,116	24,294	24,409	5,60,391	41,820
Gwalior (a)	141	7,388	556	176	9,267	692
Kashmir	..	..	..	1	55	4
Madras	336,605	21,06,161	158,358	481,826	42,81,239	319,496
Northern India	365,606	22,52,021	169,324	464,686	28,93,350	215,922
Total	1,295,144	*76,42,555*	*574,628*	1,638,749	*1,12,13,519*	*836,830*

(a) Figures relate to official years 1925-26 and 1926-27.

The total output of rock-salt decreased by 3,709 tons.

TABLE 27.—*Quantity and value of Rock-salt produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value. (£1=Rs. 13·3).		Quantity.	Value. (£1=Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range	125,470	6,39,896	48,113	122,895	6,26,760	46,773
Kohat	19,971	63,951	4,808	19,224	62,138	4,637
Mandi	4,939	1,11,239	8,364	4,552	1,02,549	7,653
Total .	150,380	*8,15,086*	*61,285*	146,671	*7,91,447*	*59,063*

There was again a decrease, amounting to 25,343 tons, in the imports of salts for which the United Kingdom was chiefly responsible. The receipts from Germany, Italian East Africa and smaller contributors were also less, while imports from Spain, Aden and Egypt shewed an appreciable increase.

TABLE 28.—*Imports of Salt into India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
From—	Tons.	Rs.	£	Tons.	Rs.	£
United Kingdom .	100,702	19,61,799	147,503	52,741	11,76,368	87,789
Germany	49,921	12,02,529	90,416	44,507	10,69,459	79,810
Spain	39,321	7,91,260	59,493	51,655	9,97,043	74,406
Aden and Dependencies	176,061	31,49,730	236,822	187,420	36,29,761	270,878
Egypt	113,085	21,20,211	159,414	122,232	24,90,858	185,885
Italian East Africa .	45,183	7,50,524	56,430	43,926	7,90,833	59,017
Other countries . .	15,068	2,71,061	20,381	13,317	2,83,448	21,153
Total .	541,141	*1,02,47,114*	*770,459*	515,798	*1,04,37,770*	*778,938*

Saltpetre.

Although statistics of production of saltpetre in India are no longer available, the export figures may be accepted as a fairly reliable index to the general state of the industry. Excepting a few hundreds of tons required for internal consumption as fertilizer, almost the whole of the output is exported to foreign countries. The quantity exported in 1926 amounted to 98,830 cwt. valued at Rs. 13,24,540 (£98,846) against 126,973 cwt. valued at Rs. 19,63,301 (£147,617) in 1925.

A certain amount of nitrate of potash is used for agricultural purposes on the Tea gardens of India. During the War when it was impossible to obtain supplies of imported potash the amount of locally produced nitrate utilized in this way reached an appreciable figure. The practice continued and the quantities estimated to have been absorbed for fertilising purposes on Tea gardens in 1923, 1924 and 1925 were 1,000, 1,100 and 800 tons respectively. In 1926 this figure is estimated to have been 700 tons. The decrease during the last two years is due to the fact that it is found cheaper to employ a mixture of imported sulphate of ammonia and muriate of potash.[1]

TABLE 29.—*Distribution of Saltpetre exported from India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·4).	
To—	Cwt.	Rs.	£	Cwt.	Rs.	£
United Kingdom	16,962	2,36,172	17,757	15,038	1,80,044	13,436
Ceylon	70,978	8,76,326	65,889	61,930	7,16,452	53,467
Straits Settlements (including Labuan).	4,652	90,743	6,823	5,567	96,833	7,226
Hongkong	21,356	4,72,040	35,492	11,281	2,39,440	17,869
Mauritius and Dependencies.	8,828	1,72,724	12,987	1,946	31,598	2,358
Other countries	4,197	1,15,296	8,669	3,068	60,173	4,490
Total	126,973	*19,63,301*	*147,617*	98,830	*13,24,540*	*98,846*

[1] From information kindly supplied by Messrs. Shaw, Wallace & Company.

Silver.

The production of silver from the Bawdwin mines of Upper Burma, which had increased to 5,287,711 oz. valued at Rs. 1,12,26,868 (£807,688) in 1924, and fallen to 4,831,548 oz. valued at Rs. 93,36,580 (£701,998) in 1925, recovered to 5,103,646 oz. valued at Rs. 88,49,722 (£660,427) in the year under review. The output of silver reported from the Kolar gold mines of Mysore decreased to the extent of 2,470 oz.

TABLE 30.—*Quantity and value of Silver produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value. (£1 = Rs. 13·3).		Quantity.	Value. (£1 = Rs. 13·4).	
	Oz.	Rs.	£	Oz.	Rs.	£
Burma—						
Northern Shan States	4,831,548	93,36,580	701,998	5,103,646	88,49,722	660,427
Madras—						
Anantapur . .	21	38	3	59	94	7
Mysore—						
Kolar . . .	24,853·3	46,571	3,502	22,388	35,222	2,629
Total .	4,856,422·3	*93,83,189*	*705,503*	5,126,088	*88,85,038*	*663,063*

Tin.

There was a considerable increase in the production of tin-ore in Burma from 2,308 tons valued at Rs. 35,63,481 (£267,931) in 1925 to 3,548 tons valued at Rs. 61,01,858 (£455,362) in 1926. The Mergui and Tavoy districts contributed to some extent to this increase but most of it was due to the production of 1,705 tons of mixed cassiterite-wolfram concentrates from the Mawchi Mines in the Southern Shan States. The composition of these concentrates is usually 43 per cent. wolfram to 57 per cent. cassiterite. For the purpose of this review 972 tons have been assumed to be cassiterite and the remainder wolfram. There is no recorded output of block tin.

The question of searching beneath the sea for tin ore along the coast of Tenasserim has recently been raised. There is little doubt that gravels brought down by the rivers and spread over the sea floor in the neighbourhood of their outlets must contain a percentage of cassiterite. Off the coasts of Java submarine tin ore has not only been proved to exist in sufficient concentration to be remunerative but is actually being worked. In the extension of the Djankang valley, about one mile southwest of Dabo tin-bearing sediments have been found to extend for a distance of ¾ mile from the shore.

Imports of unwrought tin decreased from 55,259 cwt. valued at Rs. 94,73,119 (£712,264) in 1925 to 51,023 cwt. valued at Rs. 94,72,957 (£706,937) in 1926; 96 per cent. of these imports came from the Straits Settlements. Wrought tin to the extent of 268 cwt. valued at Rs. 61,580 (£4,596) was also imported into India during the year under review.

It has recently been claimed that tin ore is associated with the sillimanite deposits of the Khasia Hills, Assam, but actual specimens have not yet been received by the Geological Survey. Officers of the Geological Survey have observed rutile—a mineral crystallographically similar to cassiterite—in association with the sillimanite.

TABLE 31.—*Quantity and value of Tin-ore produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value. (£1 = Rs. 13·3).		Quantity.	Value. (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Amherst	2	3,800	286	..	..	..
Mergui	621	10,47,511	78,760	703	12,86,522	96,009
Southern Shan States .	..	..	..	972	16,71,840	124,764
Tavoy	1,680	25,06,170	188,434	1,861	31,22,496	233,022
Thaton	5	6,000	451	12	21,000	1,567
Total .	2,308	*35,63,481*	*267,931*	3,548	*61,01,858*	*455,362*

TABLE 32.—*Imports of unwrought Tin (blocks, ingots, bars and slabs) into India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value. (£1 = Rs. 13·3).		Quantity.	Value. (£1 = Rs. 13·4).	
	Cwt.	Rs.	£	Cwt.	Rs.	£
From—						
United Kingdom .	1,3[illegible]	2,43,393	18,300	1,480	2,79,824	20,882
Straits Settlements (including Labuan).	53,607	91,76,670	689,975	49,077	90,96,626	678,853
Other countries .	2[illegible]9	53,056	3,989	466	96,507	7,202
Total .	55,250	*94,73,119*	*712,264*	51,023	*94,72,957*	*706,937*

Tungsten.

For the reason stated under "Tin" the output of wolfram was almost double the amount produced in 1925. The quantity exported from India amounted to 1,562 tons valued at Rs. 21,64,223 (£161,509) in 1926 against 2,816 tons valued at Rs. 16,89,455 (£127,027) in the preceding year. The increase of export over production is probably due to the accumulation of stocks in the years previous to 1925.

TABLE 33.—*Quantity and value of Tungsten-ore produced in India during the years 1925 and 1926.*

—	1925.			1926.		
	Quantity.	Value. (£1 = Rs. 13·3).		Quantity.	Value. (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui . . .	..	..	..	9	5,618	419
Southern Shan States	..	..	..	733	(*a*)3,58,999	26,791
Tavoy . .	772·2	4,51,864	33,975	742	4,06,347	30,325
Total .	772·2	*4,51,864*	*33,975*	1,434	*7,70,964*	*57,535*

(*a*) Estimated.

Zinc.

The production of zinc concentrates by the Burma Corporation, Ltd., in the Northern Shan States, amounted to 48,834 tons or almost thrice the amount produced in 1925. The exports during the year under review amounted to 43,056 tons valued at Rs. 43,03,775 (£321,177) against 20,967 tons valued at Rs. 20,79,794 (£156,375) in the preceding year.

III.—Minerals of Group II.

There was a further recovery in the alum industry of the Mianwali district, Punjab. The output during the year under review amounted to 2,647 cwt. valued at Rs. 50,400 (£3,761) against 1,050 cwt. valued at Rs. 22,848 (£1,718) in 1925.

Alum.

The production of amber in the Myitkyina district, Burma, rose from 16·1 cwt. valued at Rs. 9,440 (£710) in 1925 to 39·5 cwt. valued at Rs. 21,420 (£1,599) in 1926.

Amber.

There was an increase in the production of antimony in the Amherst district, Burma, from 10 tons valued at Rs. 345 (£26) in 1925 to 108 tons valued at Rs. 2,688 (£201) in 1926.

Antimony.

There was a further decrease in the production of apatite in the Singhbhum district, Bihar and Orissa, which amounted to 718 tons valued at Rs. 10,770 (£804), against 1,480 tons valued at Rs. 11,300 (£850) in 1925.

Apatite.

Of the total production of 58·4 tons of asbestos, valued at Rs. 10,529 (£786), 40 tons were produced in the Seraikela State of Bihar and Orissa and 18·4 tons in the Cuddapah district, Madras. As in the previous year the mines in the Bhandara district of the Central Provinces were not worked during the year under review.

Asbestos.

The output of barytes rose from 1,450 tons valued at Rs. 17,660 (£1,328) in 1925 to 2,311 tons valued at Rs. 9,244 (£690) in 1926; 350 tons were produced from the Kurnool district of Madras and 1,961 tons from the Alwar State of Rajputana. The fall in the price is due to the inferior quality of barytes produced in the Alwar State.

Barytes.

There was again a decrease in the total production of bauxite which fell from 10,070 tons valued at Rs. 84,055 (£6,320) in 1925 to 4,956 tons valued at Rs. 36,768 (£2,744) in 1926. Of this 2,664 tons were produced in the Kaira district of Bombay and 2,292 tons in Jubbulpore district of the Central Provinces; of the latter 1,000 tons consisted of a low-grade ore containing between 45 and 55 per cent. Al_2O_3 and used in the manufacture of Portland Cement. The mines in the Belgaum district of Bombay were not worked during the year under review.

Bauxite.

Beryl.

An output of 1,293 carats of beryl valued at Rs. 95 (£7) was reported from Ajmer-Merwara in Rajputana.

Borax is produced from the Pugga mine in the Ladak *tahsil* of Kashmir State. The mine is worked on contract and unfortunately the quantity of borax produced is not reported. The value of the production in 1926 was Rs. 30 (£2-5*s*.)

Borax.

The total estimated value of building materials and road-metal produced in the year under consideration was Rs. 1,15,31,473 (£860,558). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight. The total production of 3,095,578 tons of limestone and *kankar* includes the production of 135,429 tons of dolomite of which 135,424 tons were produced in the Gangpur State, Bihar and Orissa, mainly for use as flux in iron industries, and the remaining 5 tons in the Jaisalmer State in Rajputana for the manufacture of lime.

Building materials and road-metal.

There was again an increase in the recorded production of clay which rose from 121,148 tons valued at Rs. 2,42,785 (£18,254) in 1925 to 192,838 tons valued at Rs. 4,39,620 (£32,807) in 1926.

Clays.

TABLE 35.—*Production of Building Materials and Road Metal in India during 1926.*

(The value in sterling pounds has been calculated on the basis of £ 1=Rs. 13·4).

	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.		Marble.		Sandstone.		Slate.		Trap.		Miscellaneous.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam	2,924	474	12,112	2,858	..	..	63,325	10,834	..	..	7,460	1,610	..	..	..	..	79,009	14,013
Baluchistan	..	..	..	..	..	..	2	13	..	..	..	..	..	..	..	..	..	..
Bengal	90,000	13,433	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bihar and Orissa	20,731	3,075	1,474	38	..	..	(a)802,601	133,522	..	..	29,929	2,249	325	725	6,303	273	213,744	14,392
Bombay	26,450	12,517	1,550	281	..	..	..	..	..	..	7,500	970	..	..	275	15	732,916	50,668
Burma	460,591	81,525	130,188	20,665	..	..	187,130	27,501	..	..	71,425	9,243	..	..	..	..	500,915	46,636
Central India	..	..	..	..	13,512	11,379	70,980	4,676	..	..	..	..	..	..	..	..	5,033	2,942
Central Provinces	..	..	..	..	361	339	353,406	39,841	..	..	..	..	..	..	..	..	3,574	1,177
Gwalior	..	..	..	..	..	..	..	..	..	..	16,688	4,152	..	..	..	..	..	..
Kashmir	..	..	..	..	159	672	..	..	..	..	..	..	..	..	..	..	17,475	1,209
Madras	14,040	655	157,828	7,290	..	..	12,628	1,700	..	..	..	..	..	..	..	..	135,934	11,313
Mysore	..	..	80	(d)	1,848	1,534	6,468	1,351	..	..	..	..	..	..	..	..	2,566	862
N.W.F. Province	..	..	..	..	..	..	1,682	92	..	..	..	..	..	..	..	..	..	..
Punjab	..	..	..	..	..	..	760,031	74,693	..	..	..	..	6,253	9,812	..	..	128,948	12,754
Rajputana	..	..	..	..	..	..	(b)157,583	14,342	5,016	8,566	146,100	26,805	270	142	..	..	52,809	4,684
United Provinces	..	..	..	..	..	..	(c)678,742	72,638	..	..	9,502	2,549	1,332	352	..	..	700,061	94,957
TOTAL	614,736	111,679	303,232	30,632	15,880	13,924	3,095,578	381,203	5,016	8,566	238,604	47,578	8,180	11,031	6,578	288	2,577,984	255,657

(a) Includes 135,424 tons of dolomite.
(b) Includes 3,411 tons of *kankar* and 5 tons of dolomite.
(c) Includes 654,827 tons of *kankar* used for metalling roads.
(d) Not available.

Fuller's Earth.

The reported production of Fuller's Earth rose from 2,198 tons in 1925 to 3,456 tons in 1926. Mysore is chiefly responsible for the increased figure but its returns are not always trustworthy owing to the illiteracy of the workers. The decrease in Bikanir was almost balanced by an increase in the adjoining State of Jodhpur.

TABLE 37.—*Production of Fuller's Earth in India during the year 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value. (£1 = Rs. 13·3).		Quantity.	Value. (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Central Provinces—						
Jubbulpore	59	289	22	..	..	..
Mysore	143	364	27	1,479	3,759	281
Rajputana—						
Bikanir	1,180	7,080	533	918	5,511	411
Jaisalmer	20	310	23	21	326	24
Jodhpur	796	13,434	1,010	1,038	14,005	1,045
Total	2,198	*21,477*	*1,615*	3,456	*23,601*	*1,761*

Gypsum.

There was again a slight fall in the output of gypsum, from 36,244 tons valued at Rs. 77,270 (£5,810) in 1925 to 33,136 tons valued at Rs. 76,439 (£5,704) in 1926. The effect of gypsum in small quantities upon crops—a common application is 2 maunds to the acre—is said to be remarkable and its usefulness to the monsoon crops of South Bihar has been experimentally demonstrated.[1] The Department of Agriculture, Bihar and Orissa, is importing annually increasing amounts of gypsum from Jamsar in Bikanir. This experimental work may, therefore, ultimately result in a demand from agricultural districts for gypsum.

[1] D. Clouston. Review of Agricultural Operations in India, 1924 25, p. 52.

TABLE 38.—*Production of Gypsum in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value. (£1=Rs. 13·3).		Quantity.	Value. (£1=Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Kashmir— . . .	132	275	21	121	677	51
Punjab—						
Jhelum . . .	1,688	3,411	256	(*a*)	..	..
Rajputana—						
Bikanir . . .	26,804	57,784	4,345	24,892	55,937	4,174
Jaisalmer. . .	120	800	60	123	825	61
Jodhpur . . .	7,500	15,000	1,128	8,000	19,000	1,418
Total .	36,244	*77,270*	*5,810*	33,136	*76,439*	*5,704*

(*a*) Not reported.

Ilmenite.

There was a considerable increase in the production of ilmenite in the Travancore State, which amounted to 4,236·3 tons valued at £7,587 against 328 tons valued at £492 in 1925. This mineral is collected with the monazite sands and, up to a few years ago, was looked upon as a by-product of the monazite industry. The increasing demand for the titania in the ilmenite may prove to be a vital factor in the resuscitation of the moribund monazite industry which has been adversely affected by the increased use of electricity for lighting purposes.

Kyanite. (*See* Refractory Materials.)

Ochre.

There was a large decrease in the production of ochre, which amounted to 1,875 tons valued at Rs. 30,522 (£2,277) against 5,094 tons valued at Rs. 35,103 (£2,639) in 1925. This decrease is chiefly due to the smaller production reported from the Sohawal and Panna States in Central India. The output in the Sohawal State fell from 2,671 tons in 1925 to 425 tons in 1926 and the mines leased by the Olpherts Paints and Products, Ltd., in the Panna State, from which 1,000 tons were produced in 1925, were not worked during the year under review.

TABLE 39.—*Production of Ochre in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa	..	..	..	79	11,060	824
Central India	4,101	22,535	1,694	809	(*a*) 6,646	496
Central Provinces	119	2,410	181	75	1,500	112
Gwalior	230	4,937	371	323	6,937	518
Madras	340	4,600	346	275	3,750	280
Rajputana	304	621	47	314	629	47
Total	5,09	*35,103*	*2,639*	1,875	*30,522*	*2,277*

(*a*) Estimated.

Refractory Materials. Besides the production of 28 tons of corundum and 14 tons of garnet 1,976·5 tons of other refractory minerals including quartzite, q artz-mica-schist and quartz-kyanite-schist, valued at Rs. 21,755 (£1,624) were produced in 1926 against 6,182 tons valued at Rs. 40,192 (£3,022) in the preceding year. Of this year's production 203·5 tons were produced from the Lapso Hills mines in Kharsawan State (Singhbhum).

Serpentine. The production of serpentine in the Ladak *tahsil*, Kashmir State, fell from 2·6 tons valued at Rs. 105 (£8) in 1925 to 0·9 tons valued at Rs. 37 (£3) in 1926.

Soda. The production of soda in the Ladak *tahsil*, Kashmir, fell from 28·3 tons, valued at Rs. 1,126 (£85) in 1925 to 20 tons valued at Rs. 733 (£55) in 1926. Salt, consisting for the greater part of sodium carbonate, sodium bicarbonate and sodium chloride, is obtained by evaporation from the waters of the Lonar lake in the Buldana district of the Central Provinces. It is known under the general name of *trona* or *urao*, for which there is no suitable equivalent in English. The total amount of *trona* extracted in 1926 was 100 tons, the value of which was estimated at Rs. 3,000 (£224) as against 35 tons, valued at Rs. 1,050 (£79) in 1925. There was also a production of 3 tons

of crude soda (*rasi*), valued at Rs. 82 (£6) in Datia State, Central India.

Steatite.

The great fall in the output of steatite in 1924 was followed by an enormous increase in 1925, amounting to 5,673 tons, mainly due to the inclusion of the output reported from the Jaipur State in Rajputana. In 1926 there was a further increase in the quantity produced accompanied by a marked decline in total value

TABLE 40.—*Production of Steatite in India during the years 1925 and 1926.*

	1925.			1926.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj . .	90·0	8,350	628	65·0	6,900	515
Seraikela . .	25·7	1,400	105	11·0	600	45
Singhbhum . .	58·9	3,530	266	2,648·0	29,742	2,220
Burma—						
Pakokku Hill Tracts .	3·1	800	60	17·0	5,808	433
Central India—						
Bijawar . . .	202·2	1,920	144	208·0	1,972	147
Central Provinces—						
Bhandara . .	337·5	13,500	1,015	..	..	..
Jubbulpore . .	1,286·8	70,799	5,323	890·0	16,439	1,227
Madras—						
Kurnool . . .	4·0	244	18	3·0	210	16
Nellore . . .	82·2	5,724	430	65·0	2,411	180
Salem . . .	712·8	16,697	1,256	480·0	12,549	936
Mysore— . . .	101·0	303	23	80·5	243	18
Rajputana—						
Jaipur . . .	5,514·0	70,000	5,263	5,074·0	64,200	4,791
United Provinces—						
Hamirpur . .	31·0	7,040	530	78·0	8,686	648
Jhansi . . .	76·0	770	58	54·0	500	37
Total .	8,525·2	*2,01,086*	*15,119*	9,673·5	*1,50,260*	*11,213*

Zircon.

There was a slight decrease in the production of zircon in the Travancore State, which fell from 576 tons valued at £4,608 in 1925 to 532 tons valued at £2,987 in 1926.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 41.—*Statement of Mineral Concessions granted during the year 1926.*

AJMER-MERWARA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ajmer .	(1) L. Lachmi Ram Mool Chand of Nasirabad.	Mica . . .	P. L. .	1·76	19th January 1926.	1 year.
Do. .	(2) Messrs. Shamshuddin and Sons of Nasirabad.	Do. . . .	P. L. .	4·46	25th January 1926.	Do.
Do. .	(3) M. Mohammed Sarfaraz Ali of Ajmer.	Do. . . .	P. L. .	1·99	13th March 1926.	Do.
Do. .	(4) Mr. Dhirajlal Pershotam of Nashirabad.	Do. . . .	P. L. .	1·52	22nd March 1926.	Do.
Do. .	(5) Mr. Nusserwanji Dadabhoy of Ajmer.	Do. . . .	P. L. .	2	13th May 1926.	Do.
Do. .	(6) K. Govardhan Lal Rathi of Nasirabad.	Red oxide .	P. L. .	2	16th May 1926.	Do.
Do. .	(7) Mr. Dhirajlal Pershotam of Nashirabad.	Mica . .	P. L. .	1·28	22nd May 1926.	Do.
Do. .	(8) Mr. E. P. Thomas, Mining Engineer, Ajmer.	Do. . . .	P. L. .	1·05	3rd August 1926.	Do.
Do. .	(9) L. Kanhya Lal of Nasirabad.	Do. . . .	P. L. (renewal).	5·11	4th September 1926.	Do.
Do. .	(10) Do. . .	Do. . . .	P. L. (renewal).	3·62	Do. .	Do.
Do. .	(11) K. Govardhan Lal Rathi of Nasirabad.	Do. . . .	P. L. .	5·28	9th September 1926.	Do.
Do. .	(12) L. Chhaganlal of Nasirabad.	Do. . . .	P. L. .	1·48	16th September 1926.	Do.
Do. .	(13) Mr. Dhirajlal Pershotam of Nasirabad.	Do. . . .	P. L. .	3·12	27th September 1926.	Do.
Do. .	(14) L. Chhaganlal of Nasirabad.	Do. . . .	P. L. (renewal).	17·15	30th September 1926.	Do.
Do. .	(15) Do. . .	Do. . . .	P. L. (renewal).	4·32	Do. .	Do.
Do. .	(16) Do. . .	Do. . . .	P. L. (renewal).	1	Do. .	Do.
Do. .	(17) The Manager, Rajputana Mineral Co., Ltd., Ajmer.	Do. . . .	M. L. .	0·36	25th March 1926.	10 years.
Do. .	(18) Do. . .	Do. . . .	M. L. . .	4·29	Do. .	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

AJMER-MERWARA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ajmer .	(19) L. Lachmiram Moolchand of Nasirabad.	Mica . . .	M. L. .	Not stated.	9th March 1926.	3 years.
Do. .	(20) Messrs. Radhakissen Kanhyalal of Nasirabad.	Do. . .	M. L. .	Do.	12th May 1926.	5 years.
Do. .	(21) Messrs. Lachmi Ram Moolchand of Nashirabad.	Do. . .	M. L. .	Do.	16th February 1926.	3 years.
Beawar .	(22) Mr. Abdul Aziz Shad of Beawar.	Asbestos . .	P. L. .	4	16th April 1926.	1 year.
Do. .	(23) L. Premsukh Rathi of Nasirabad.	Mica . .	P. L. .	6·56	12th June 1926.	Do.
Do. .	(24) Do. . .	Do. . . .	P. L. .	1·66	Do. .	Do.
Do. .	(25) M. Mohammed Sarfar Ali of Ajmer.	Do. . . .	P. L. .	2·78	17th June 1926.	Do.
Do. .	(26) The General Manager, Rajputana Minerals Co., Ltd., Ajmer.	Do. . . .	P. L. .	0·41	24th June 1926.	Do.
Do. .	(27) Do. . .	Do. . . .	P. L. .	7	Do. .	Do.
Do. .	(28) Do. . .	Do. . . .	P. L. .	7	Do. .	Do.
Do. .	(29) M. Abdul Aziz Shad of Beawar.	Do. . . .	P. L. .	3·1	4th September 1926.	Do.
Do. .	(30) Messrs. Abdulla & Sons, Ajmer.	Do. . . .	P. L. .	2·	9th October 1926.	Do.
Do. .	(31) M. Abdul Aziz Shad of Beawar.	Do. . . .	P. L. .	7·57	20th November 1926.	Do.
Do. .	(32) M. Mohamed Fazil of Ajmer.	Do. . . .	P. L. .	2·54	10th December 1926.	Do.
Do. .	(33) Do. . .	Do. . . .	M. L. .	0·97	27th July 1926.	10 years.

ASSAM.

Cachar .	(34) Burma Oil Company, Ltd.	Mineral oil .	P. L. .	755·2	25th November 1926.	2 years.
Do. .	(35) Do. . .	Do. . . .	P. L. .	755·2	Do. .	Do.
Do. .	(36) Do. . .	Do. . . .	P. L. .	6,169·6	6th April 1926.	Do.
Do. .	(37) Do. . .	Do. . . .	P. L. .	4,409·6	12th April 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

ASSAM—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Garo Hills .	(38) Garo Hills Corporation, Ltd.	Coal . . .	P. L.	4,320	9th May 1926.	1 year.
Do. .	(39) Do. . .	Do. . . .	P. L. .	800	Do. .	Do.
Do. .	(40) Do. . .	Do. . . .	P. L. .	640	Do. .	Do.
Do. .	(41) Do. . .	Do. . . .	P. L. .	445	Do. .	Do.
Do. .	(42) Do. . .	Do. . . .	P. L. .	350	Do. .	Do.
Do. .	(43) Do. . .	Do. . . .	P. L. .	147	Do. .	Do.
Khasi and Jaintia Hills.	(44) Mr. R. A. Leitch	Copper, gold, lead, etc., (minerals other than mineral oil).	P. L. .	5,427	30th July 1926.	Do.
Do. .	(45) Do. . .	Mineral Oil .	P. L. .	5,427	Do. .	Do.
Do. .	(46) Garo Hills Mining Syndicate.	Coal . . .	P. L. (renewal).	2,880	6th November 1926.	Do.
Lakhimpore	(47) Assam Oil Co., Ltd.	Oil . . .	P. L. .	1,792	25th October 1926.	2 years.
Do. .	(48) Do. . .	Do. . . .	P. L. (renewal).	5,120	30th March 1926.	1 year.
Do. .	(49) Do. . .	Do. . . .	P. L. (renewal).	4,480	7th April 1926.	Do.
Do. .	(50) Do. . .	Do. . . .	P. L. (renewal).	4,160	20th April 1926.	Do.
Do. .	(51) Do. . .	Do. . . .	P. L. (renewal).	3,968	12th May 1926.	Do.
Do. .	(52) Do. . .	Do. . . .	P. L. (renewal).	9,792	7th October 1926.	Do.
Do. .	(53) Do. . .	Coal . . .	P. L. (renewal).	3,328	5th February 1926.	Do.
Do. .	(54) Do. . .	Oil . . .	P. L. (renewal).	853	23rd April 1926.	Do.
Do. .	(55) Do. . .	Coal .	P. L. (renewal).	9,792	7th October 1926.	Do.
Manipur .	(56) Mr. D. D. Mukherjee.	Copper . .	M. L. .	500	1st January 1926.	30 years.
Nowgong .	(57) Messrs. The Whitehall Petroleum Corporation, Ltd.	Crude Petroleum and its Associated hydrocarbons.	P. L. (renewal).	1,920	20th March 1926.	1 year.
Do. .	(58) Do. . .	Do. . .	P. L. (renewal).	1,344	Do. .	Do.
Do. .	(59) Do. . .	Do. . .	P. L. (renewal).	1,344	9th April 1926.	Do.
Sadiya Frontier Tract.	(60) The Assam Oil Co., Ltd.	Mineral oil .	P. L. (renewal).	2,240	19th December 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Sibsagar .	(61) Messrs. The Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated hydrocarbons.	P. L. .	1,388·8	24th July 1926.	1 year.
Do. .	(62) The Assam Oil Co., Ltd.	Coal and oil .	P. L. . (renewal).	1,440	5th June 1926.	Do.
Do. .	(63) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. . . (renewal).	6,400	9th June 1926.	Do.
Sylhet .	(64) Do. . .	Mineral oil .	P. L. .	4,696	10th November 1926.	2 years.

BALUCHISTAN.

Sibi . .	(65) Messrs. The Indo-Burma Petroleum Co., Ltd., and the Burma Oil Co., combined.	Petroleum .	E. L. .	42,240	25th March 1927.	3 years.

BENGAL.

Chittagong	(66) Messrs. The Whitehall Petroleum Corporation, Ltd.	Natural petroleum	P. L. .	3,061·98	16th June 1926.	1 year.
Do. .	(67) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	4,000	9th March 1926.	2 years.
Chittagong Hill Tracts.	(68) Messrs. The Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated hydrocarbons.	P. L. . (renewal).	4,601·6	14th April 1926.	1 year.
Do. .	(69) Messrs. The Burma Oil Co., Ltd.	Mineral oil .	P. L. . (renewal).	4,313·6	7th March 1926.	Do.
Do. .	(70) Messrs. The Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated hydrocarbons.	P. L. . (renewal).	2,912	3rd September 1926.	Do.
Do. .	(71) Do. . .	Do. . .	P. L. . (renewal).	5,401·6	14th April 1926.	Do.

BIHAR AND ORISSA.

Gaya . .	(72) Mr. D. C. Nag .	All minerals except oil and coal.	P. L. .	480	17th December 1926.	1 year.
Singhbhum	(73) Mr. Indra Singh	Chromite . .	P. L.	952	10th April 1926.	Do.
Do. .	(74) Mangi Lal Marwari.	Iron ore . .	M. L. .	224	6th April 1926.	5 years.

P. L. = Prospecting License. *M. L. = Mining Lease.* *E. L. = Exploring License.*

BOMBAY.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kanara .	(75) Mr. T. B. Kantharia.	Manganese .	M. L. .	116	30th October 1926.	3 years.

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(76) Messrs. The Burma Oil Co., Ltd., Rangoon.	Natural petroleum.	P. L. .	4,480	28th July 1926.	2 years.
Do. .	(77) Do. . .	Do. . .	P. L. .	9,408	16th January 1926.	Do.
Do. .	(78) The Indo-Burma Petroleum Co., Rangoon.	Do. . .	P. L. (renewal).	4,800	19th January 1926.	1 year.
Do. .	(79) Do. . .	Do. . .	P. L. (renewal).	1,280		
Do. .	(80) The Whitehall Petroleum Corporation, Ltd.	Do. . .	P. L. (renewal).	5,120	26th August 1926.	1 year.
Amherst .	(81) H. Bryant . .	All minerals except Oil.	P. L. .	1,280	2nd February 1926.	Do.
Do. .	(82) Major L. Sisman.	Do. . .	P. L. .	505·6	Do. .	Do.
Do. .	(83) Messrs. Talaing Tin, Ltd.	Do. . .	P. L. .	2,432	28th January 1926.	Do.
Do. .	(84) H. J. Davies .	Do. . .	P. L. .	601·6	20th July 1926.	Do.
Do. .	(85) A. C. Martin .	Do. . .	P. L. .	1,280	21st July 1926.	Do.
Do. .	(86) Do. . .	Do. .	P. L. .	640	18th October 1926.	Do.
Do. .	(87) U. Pe . .	Do. . .	P. L. .	320	10th November 1926.	Do.
Do. .	(88) L. Ah Choy .	Do. . .	P. L. .	640	14th July 1926.	Do.
Do. .	(89) A. C. Jeeva .	Do. . .	P. L. .	588·8	12th June 1926.	Do.
Do. .	(90) Messrs. Talaing Tin, Ltd.	Do. . .	P. L. .	2,560	20th August 1926.	Do.
Do. .	(91) Do. .	Do. . .	P. L. .	3,840	18th August 1926.	Do.
Do. .	(92) Saw Eu Hoke .	Do. . .	P. L. .	1,280	2nd November 1926.	Do.
Do. .	(93) Mr. S. H. Harman	Do. . .	P. L. .	640	20th August 26.	Do.
Do. .	(94) Dr. K. S. Kanga	Do. . .	P. L. .	549·76	6th December 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*
* Extended till mining lease is issued.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(95) Messrs. Hossain Hamadanee Mirza A. Hosain.	All minerals except oil.	P. L. .	1,008	24th October 1926.	1 year.
Do. .	(96) Mr. S. H. Harman	Do. .	P. L. .	3,840	11th November 1926.	Do.
Do. .	(97) Messrs. Balthazar & Sons.	Oil shale . .	P. L. . (renewal).	5,760	22nd January 1926.	Do.
Do. .	(98) Dr. M. Shawloo	Do. . .	P. L. . (renewal).	7,040	5th March 1926.	Do.
Do. .	(99) Saw Lein Lee .	Antimony . .	P. L. . (renewal).	1,600	6th June 1926.	Do.
Do. .	(100) D. A. David .	Sulphides . .	P. L. . (renewal).	1,280	30th July 1926.	Do.
Do. .	(101) Saw Lein Lee .	Antimony . .	P. L. . (renewal).	1,248	17th June 1926.	Do.
Do. .	(102) H. Bryant .	All minerals except oil.	P. L. . (renewal).	1,280	10th July 1926.	Do.
Do. .	(103) Saw Lein Lee .	Antimony . .	P. L. . (renewal).	1,280	16th September 1926.	Do.
Kyaukse .	(104) Mr. A. J. Beale	All minerals except oil.	P. L. .	1,849·6	7th October 1926.	Do.
Lower Chindwin.	(105) The Indo-Burma Petroleum Co., Ltd.	Natural petroleum.	P. L. .	5,760	5th July 1926.	Do.
Do. .	(106) Mr. Lawrence Dawson.	Do. .	P. L. .	1,196·8	6th February 1926.	Do.
Do. .	(107) The Indo-Burma Petroleum Co., Ltd.	Do. .	P. L. . (renewal).	5,798·4	24th September 1926.	Do.
Do. .	(108) Do. .	Do. .	P. L. . (renewal).	1,600	22nd September 1926.	Do.
Do. .	(109) Messrs. The Burma Oil Co., Ltd.	Do. .	P. L. . (renewal).	640	24th January 1926.	Do.
Magwe .	(110) Do. .	Do. .	P. L. .	160	8th February 1926.	2 years.
Do. .	(111) Do. .	Do. .	P. L. .	2,560	(*a*)	Do.
Do. .	(112) U. Maung Gyi	Do. .	P. L. .	96	21st January 1926.	Do.
Do. .	(113) Messrs. The Burma Oil Co., Ltd.	Do. .	P. L. .	640	2nd September 1926.	Do.
Mandalay .	(114) Messrs. The Burma Corporation, Ltd.	Iron-ore .	M. L. .	11·96	16th September 1926.	20 years.
Do. .	(115) Messrs. Steel Bros. & Co., Ltd.	All minerals except oil.	P. L. . (renewal).	1,996·8	1st October 1926.	1 year.
Meiktila .	(116) Mr. Aldworth .	Do. .	P. L. .	960	14th October 1926.	Do.
Do. .	(117) Mr. Colin Campbell.	Do. .	P. L. .	640	4th August 1926.	Do.

P. L. = *Prospecting License.* *M. L.* = *Mining Lease.*

(*a*) The license was sanctioned on the 8th September 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Meiktila .	(118) Mr. Colin Campbell.	All minerals except oil.	P. L. .	1,600	27th October 1926.	1 year.
Mergui .	(119) Mr. P. B. O. Watson.	Tin and allied minerals.	P. L. .	588·8	9th August 1926.	Do.
Do. .	(120) Ma Kyon .	Do. .	P. L. .	1,337·6	16th February 1926.	Do.
Do. .	(121) En Gwan Kyin	Tin . . .	P. L. .	1,580·8	4th May 1926.	Do.
Do. .	(122) Mr. C. Beadon .	Do. . . .	P. L. .	1,273·6	18th February 1926.	Do.
Do. .	(123) Do. .	Do. . . .	P. L. .	1,152	9th April 1926.	Do.
Do. .	(124) Mr. S. Warwick Smith.	All minerals except oil.	P. L. .	1,267·2	13th January 1926.	Do.
Do. .	(125) Messrs. Mayan Chaung Alluvials, Ltd.	Tin and allied minerals.	P. L. .	1,152	Do. .	Do.
Do. .	(126) Mr. Joo Seng .	All minerals except oil.	P. L. .	960	20th November 1926.	Do.
Do. .	(127) Mr. S. O. Holmes	Do. .	P. L. .	620·8	3rd February 1926.	Do.
Do. .	(128) Mr. Rowland Ady.	Do. .	P. L. .	3,202·9	(*a*)	
Do. .	(129) In Sit Yan .	Do. .	P. L. .	595·2	13th January 1926.	Do.
Do. .	(130) Leong Ah Foo .	Tin and allied minerals.	P. L. .	524·8	28th August 1926.	Do.
Do. .	(131) Mr. J. I. Milne	All minerals except oil.	P. L. .	627·2	3rd February 1926.	Do.
Do. .	(132) Mr. A. S. Mohamed.	Tin and other allied metals.	P. L. .	352	9th April 1926.	Do.
Do. .	(133) Dr. San Moe .	Tin and allied minerals.	P. L. .	236·8	9th August 1926.	Do.
Do. .	(134) In Sit Yan .	Tin and other minerals.	P. L. .	211·2	9th April 1926.	Do.
Do. .	(135) Mr. Geo. W. Bowden.	Tin and all minerals except coal and mineral oil.	P. L. .	352	3rd February 1926.	Do.
Do. .	(136) Leong Foke Hye	Tin and allied minerals.	P. L. .	281·6	9th April 1926.	Do.
Do. .	(137) Mr. A. Aziz Yunose.	All minerals except oil.	P. L. .	537·6	9th August 1926.	Do.
Do. .	(138) In Sit Yan .	Tin and other minerals.	P. L. .	460·8	31st July 1926.	Do.
Do. .	(139) Maung Pe Kin .	Do. .	P. L. .	3,590·4	(*b*)	Do.
Do. .	(140) Leong Foke Hye	Tin and allied minerals.	P. L. .	1,292·8	23rd August 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

(*a*) The license was sanctioned on the 23rd July 1926.
(*b*) The license was sanctioned on the 12th April 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(141) Tan Sine Shin .	Tin	P. L. .	454·4	9th April 1926.	1 year.
Do. .	(142) Mr. Joo Seng .	Do.	P. L. .	473·6	9th August 1926.	Do.
Do. .	(143) Maung Pe Kin	Do.	P. L. .	908·8	6th November 1926.	Do.
Do. .	(144) Gul.Mohamed .	Wolfram and tin	P. L. .	576	31st July 1926.	Do.
Do. .	(145) Maung E. Gyi .	Tin and allied minerals.	P. L. .	256	14th June 1926.	Do.
Do. .	(146) Mr. F. L. Watts	Tin ore . . .	P. L. .	1,196·8	9th August 1926.	Do.
Do. .	(147) Messrs. Mayan Chaung Alluvials, Ltd.	Do. . . .	P. L. .	960	24th July 1926.	Do
Do. .	(148) Ma Kyin Mya and Ma Lin.	Do. . . .	P. L. .	441·6	4th May 1926	Do.
Do. .	(149) Mr. P. B. O. Watson.	Tin and allied minerals.	P. L. .	2,560	31st July 1926.	Do.
Do. .	(150) Mr. G. H. Hand	Tin	P. L. .	806·4	24th June 1926.	Do.
Do. .	(151) Mr. E. Maxwell Lefroy.	All minerals except oil.	P. L. .	684·8	30th October 1926.	Do.
Do. .	(152) Mr. Henry E. Wells.	Tin and allied minerals.	P. L. .	320	12th April 1926.	Do.
Do. .	(153) Mr. F. L. Watts	Cassiterite and other ores of tin.	P. L. .	256	9th August 1926.	Do.
Do. .	(154) Mr. Joo Seng .	Tin ore . . .	P. L. .	544	9th August 1926.	Do.
Do. .	(155) Do. .	All minerals except oil.	P. L. .	160	2nd December 1926.	Do.
Do. .	(156) Tan E. Kyin .	Tin and other minerals except oil.	P. L. .	121·6	27th August 1926.	Do.
Do. .	(157) Mr. E. B. Milne.	All minerals except mineral oil.	P. L. .	1,254·4	1st December 1926.	Do.
Do. .	(158) Mr. J. I. Milne. .	Do. .	P. L. .	217·6	31st July 1926.	Do.
Do. .	(159) Mr. Lee Quee Chee.	Tin and allied minerals	P. L. .	3,289·6	(*a*)	Do.
Do. .	(160) Mr. Leslie R. Beale.	Do. .	P. L. .	236·8	21st December 1926.	Do.
Do. .	(161) Mr. G. H. Hand	Tin	P. L. .	2,918·4	4th September 1926.	Do.
Do. .	(162) Maung Pe Kin .	Tin and allied minerals.	P. L. .	280·4	1st December 1926.	Do.
Do. .	(163) Mr. G. H. Hand	Tin	P. L. .	1,017·6	Do.	Do.

P. L. = *Prospecting License.* *M. L.* = *Mining Lease.*
(*a*) The license was sanctioned on the 10th December 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(164) Dr. James Morrow Campbell.	Tin and gold .	P. L. .	512	(e)	1 year.
Do. .	(165) Mr. E. B. Milne. .	All minerals except oil.	P. L. .	172·8	1st November 1926.	Do.
Do. .	(166) Ma Kyon . .	Tin and allied minerals.	P. L. .	211·2	8th December 1926.	Do.
Do. .	(167) Maung Po .	Tin and all minerals except oil.	P. L. .	384	22nd December 1926.	Do.
Do. .	(168) Ah Shee . .	Tin and allied minerals.	P. L. .	640	30th October 1926.	Do.
Do. .	(169) Mr. Geo. W. Bowden.	Mixed tin ore .	P. L. .	544	19th October 1926.	Do.
Do. .	(170) Mr. S. W. Smith	Tin and all other minerals except oil and coal.	M. L.	1,971·2	1st October 1926.	30 years.
Do. .	(171) Ma Kyon .	Tin . . .	P. L. (renewal).	128	15th January 1926.	1 year.
Do. .	(172) Mr. E. Ahmed .	Do. . . .	P. L. (renewal).	192	26th March 1926.	Do.
Do. .	(173) Mr. A. S. Mohamed.	Do. . . .	P. L. (renewal).	774·4	Do.	Do.
Do. .	(174) Mr. H. Kim Chu.	Tin and allied minerals.	P. L. (renewal).	620·8	20th April 1926.	Do.
Do. .	(175) Maung San Dun	Do. .	P. L. (renewal).	185·6	4th April 1926.	Do.
Do. .	(176) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals except mineral oil.	P. L. (renewal).	262·4	8th April 1926.	Do.
Do. .	(177) Mr. Geo. W. Bowden.	Tin ore and wolfram.	P. L. (renewal).	627·2	4th April 1926.	Do.
Do. .	(178) Ma Kyon .	Tin . . .	P. L. (renewal).	352	20th May 1926	Do.
Do. .	(179) Do. .	Do. .	P. L. (renewal).	153·6	30th July 1926.	Do.
Do. .	(180) Mr. Joo Seng .	All minerals except oil.	P. L. (renewal).	345·6	1st August 1926.	Do.
Minbu .	(181) Mr. L. Dhana Singh.	Natural petroleum	P. L. .	320	10th March 1926.	Do.
Do. .	(182) Do. .	Do. .	P. L. .	588·8	30th April 1926.	Do.
Do. .	(183) Messrs. The Burma Oil Co., Ltd.	Do. .	P. L. (renewal).	640	23rd January 1926.	Do.
Myingyan .	(184) Messrs. The Yenangyaung Oil Field, Southern Extension, Ltd.	Do. .	P. L. .	1,280	27th September 1926.	2 years.
Do. .	(185) Mr. Baijnath Singh.	Do. . .	M. L. .	2,675·2	1st July 1926	10 years

P. L. = Prospecting License. *M. L. = Mining Lease.*
(e) The license was sanctioned on the 16th November 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Northern Shan States.	(186) General Manager, Burma Corporation, Ltd., Namtu.	Iron ore . .	P. L. .	121·6	1st July 1926	1 year.
Do. .	(187) Do. .	Do. .	P. L. .	256	Do. .	Do.
Do. .	(188) Mr. A R. Overlander, Namtu.	Lead and Silver .	P. L. .	1,920	9th November 1926.	Do.
Pakôkku .	(189) Messrs. The Nath Singh Oil Co., Ltd.	Natural petroleum	P. L. .	7,520	14th April 1926.	2 years.
Do. .	(190) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. .	M. L. .	1,900·8	11th February 1926.	30 years.
Do. .	(191) Mr. Baijnath Singh.	Do. .	M L. .	1,440	1st June 1926.	Do.
Do. .	(192) Ma Zau . .	Do. .	P. L. . (renewal).	99	29th June 1925.	1 year.
Do. .	(193) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. . (renewal).	800	7th November 1925.	Do.
Do. .	(194) Messrs. The British Burma Petroleum Co., Ltd.	Do. .	P. L. . (renewal).	2,880	1st December 1926.	Do.
Do. .	(195) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. .	P. L. . (renewal).	2,400	12th February 1926.	Do
Shwebo .	(196) Do. .	Do. .	P. L. . (renewal).	5,113·6	12th March 1926.	Do.
Do.	(197) Do. .	Do. .	P. L. . (renewal).	5,440	14th August 1926.	Do.
Southern Shan States.	(198) Messrs. Steel Bros. & Co., Ltd.	All minerals except oil.	P. L. .	640	29th March 1926.	Do.
Do. .	(199) Ma Saw Lon .	Do. .	P. L. .	1,536	16th March 1926.	Do.
Do. .	(200) J. W. Ryan .	Do. .	P. L. .	640	21st August 1926.	Do.
Do. .	(201) H. Abdul Shakoor Hajee Cassim & Son.	Do. .	P. L. .	2,291·2	15th November 1926.	Do.
Do. .	(202) Mr. Colin Campbell.	Do. .	P. L. .	640	26th February 1926.	Do.
Do. .	(203) Messrs. Steel Bros. & Co., Ltd.	Do. .	P. L. .	4,480	17th March 1926.	Do.
Do. .	(204) Mr. Tan Po Yin	Do. .	P. L. .	640	4th May 1926	Do.
Do. .	(205) Messrs. Steel Bros. & Co., Ltd.	Do. .	P. L. .	236·8	26th July 1926	Do.
Do. .	(206) Do. .	Do. .	P. L. .	480	Do. .	Do.
Do. .	(207) Do. .	Do. .	P. L. .	2,880	(*a*)	Do.
Do. .	(208) Do. .	Do. .	P. L. .	2,560	(*b*)	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

(*a*) The license was sanctioned on the 2nd February 1926.

(*b*) The license was sanctioned on the 6th April 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(209) Messrs. Steel Bros. & Co., Ltd.	All minerals except oil.	P. L.	13,875·2	(*a*)	1 year.
Do.	(210) Do.	Do.	P. L.	2,880	(*b*)	Do.
Do.	(211) Mr. Tan Poyiu	Lead and Silver	M. L.	40	24th March 1926.	10 years.
Do.	(212) Messrs. Steel Bros. & Co., Ltd.	All minerals except natural petroleum.	M. L.	4,172·8	28th May 1926.	30 years.
Do.	(213) Mr. Colin Campbell.	All minerals except oil.	P. L. (renewal).	2,240	25th November 1926.	1 year.
Do.	(214) Do.	Do.	P. L. (renewal).	640	Do.	Do.
Do.	(215) Daw Mi & Son	Do.	P. L. (renewal).	640	31st December 1926.	Do.
Do.	(216) Mr. C. E. Browne.	Gold.	P. L. (renewal).	640	17th August 1926.	2 years.
Tavoy	(217) Tavoy Tin Dredging Corporation, Ltd.	Tin and wolfram	P. L.	1,196·8	27th February 1926.	1 year.
Do.	(218) Burma Finance and Mining Co., Ltd.	Do.	P. L.	569·6	11th June 1926.	Do.
Do.	(219) Mrs. S. Wellington.	Do.	P. L.	1,337·6	16th February 1926.	Do.
Do.	(220) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do.	P. L.	3,033·6	30th January 1926.	Do.
Do.	(221) Mr. H. N. Wilkins.	Do.	P. L.	121·6	18th January 1926.	Do.
Do.	(222) Mr. M. A. Musaji	Do.	P. L.	640	19th February 1926.	Do.
Do.	(223) U. Maung Maung.	Do.	P. L.	320	26th May 1926.	Do.
Do.	(224) Mr. Ali Adjim Soratee.	Do.	P. L.	537·6	23rd March 1926.	Do.
Do.	(225) Maung Ba Bwa	Do.	P. L.	614·4	13th February 1926.	6 months.
Do.	(226) Mr. Ong Hoe Kyiu.	Do.	P. L.	115·2	7th May 1926	1 year.
Do.	(227) Ma Yai	Do.	P. L.	108·8	Do.	Do.
Do.	(228) U. Maung Maung.	Do.	P. L.	160	26th May 1926.	Do.
Do.	(229) Mr. H. Kine Chu.	Do.	P. L.	320	16th February 1926.	Do.
Do.	(230) Mr. J. W. Newbery.	Do.	P. L.	34·56	5th March 1926.	Do.
Do.	(231) Mr. Yeo Kyi Hau.	Do.	P. L.	1,113·6	1st July 1926	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

(*a*) The license was sanctioned on the 28th May 1926.

(*b*) The license was sanctioned on the 10th June 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(232) Mr. Wong Cheuk	Tin and wolfram .	P. L. .	1,785·6	26th March 1926.	1 year.
Do. .	(233) Mr. H. Kine Chu.	Do. .	P. L. .	339·2	17th March 1926.	6 months.
Do. .	(234) Mr. S. Wellington.	Do. .	P. L. .	640	5th May 1926	1 year.
Do. .	(235) Eu Shwe Swai .	Do. .	P. L. .	800	24th June 1926.	6 months.
Do. .	(236) Ung Kyee Pe .	Do. .	P. L. .	556·8	8th July 1926	1 year.
Do. .	(237) Ong Hoe Kyin .	Do. .	P. L. .	64	27th March 1926.	Do.
Do. .	(238) Mr. M. A. Musaji	Do. .	P. L. .	640	19th February 1926.	Do.
Do. .	(239) Quah Cheng Tock.	Do. .	P. L. .	512	10th June 1926.	Do.
Do. .	(240) Maung Ba Bwa.	Do. .	P. L. .	640	10th May 1926.	6 months.
Do. .	(241) The Burma Finance and Mining Co., Ltd.	Do. .	P. L. .	697·6	6th September 1926.	1 year.
Do. .	(242) Mr. W. Ross .	Do. .	P. L. .	1,011·2	3rd July 1926	Do.
Do. .	(243) Maung Ba Bwa .	Do. .	P. L. .	640	17th May 1926.	6 months.
Do. .	(244) The Burma Finance and Mining Co., Ltd.	Do. .	P. L. .	89·6	17th November 1926.	1 year.
Do. .	(245) Mr. Ali Adjine Soratee.	Do. .	P. L. .	640	2nd July 1926	Do.
Do. .	(246) Mr. J. J. A. Page	Cassiterite and wolfram.	P. L. .	217·6	12th July 1926.	Do.
Do. .	(247) Maung Po Swe .	Tin and wolfram	P. L. .	640	7th September 1926.	Do.
Do. .	(248) Quah Cheng Quan.	Do. .	P. L. .	76·8	10th June 1926.	Do.
Do. .	(249) Mr. H. Kine Chu	Do. .	P. L. .	179·2	4th June 1926.	Do.
Do. .	(250) Maung Ngwe Thi	Do. .	P. L. .	588·8	7th June 1926.	Do.
Do. .	(251) Dr. K. S. Kanga	Do. .	P. L. .	1,920	6th December 1926.	Do.
Do. .	(252) Maung E. Zin .	Do. .	P. L. .	1,459·2	26th August 1926.	Do.
Do. .	(253) Mr. Wong Cheuk	Do. .	P. L. .	44·8	2nd July 1926.	Do.
Do. .	(254) Messrs. J. W. Newbery and F. F. Ward.	Do. .	P. L. .	179·2	9th August 1926.	Do.

P. L. = Prospecting License.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(255) Maung Ngwe Thi	Tin and wolfram .	P. L. .	640	5th July 1926.	1 year.
Do. .	(256) Mr. J. J. A. Page	Cassiterite . .	P. L. .	211·2	2nd November 1926.	Do.
Do. .	(257) Maung Ba Oh .	Tin and wolfram .	P. L. .	320	13th August 1926.	Do.
Do. .	(258) The Tavoy Rubber Co., Ltd.	Do. .	P. L. .	12·8	3rd December 1926.	Do.
Do. .	(259) Do. .	Do. .	P. L. .	595·2	12th October 1926.	Do.
Do. .	(260) Mr. J. M. Watt	Do. .	P. L. .	435·2	9th August 1926.	Do.
Do.	(261) Ung Kyee Pe .	Do. .	P. L. .	640	18th August 1926.	Do.
Do. .	(262) Mg. Ngwe Thi .	Do. .	P. L. .	512	9th December 1926.	Do.
Do. .	(263) Mr. H. C. Flanders.	Do. .	P. L. .	640	2nd December 1926.	Do.
Do. .	(264) Eu Shwe Swai .	Do. .	P. L. .	512	26th November 1926.	Do.
Do. .	(265) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	All minerals except natural petroleum.	P. L. .	25,120	(*a*)	Do.
Do. .	(266) Mr. J. J. A. Page	Cassiterite, wolframite and molybdenite.	P. L. .	4,288	(*b*)	6 months.
Do. .	(267) Messrs. The Burma Finance and Mining Co., Ld.	Tin and wolfram	M. L. .	171·52	6th January 1925.	30 years.
Do. .	(268) Do. .	Do. .	M. L. .	340·48	1st October 1925.	Do.
Do. .	(269) Mr. Ong Hoe Kyin.	Do. .	M. L. .	219·5	1st June 1926.	Do.
Do. .	(270) Mr. R. C. N. Twite.	Tin and allied minerals.	M. L. .	117·7	Do.	Do.
Do. .	(271) Mr. A. W. Ross	Tin	M. L. .	1,654·4	1st July 1926	15 years.
Do. .	(272) Mr. T. J. Mackey	Do.	M. L. .	491·5	Do. .	10 years.
Do. .	(273) Mr. W. C. Toms	Tin, wolfram and bismuth.	M. L. .	819·8	16th July 1926.	30 years.
Do. .	(274) Maung Ni Toe .	Tin and wolfram	M. L. .	160	1st October 1926.	25 years.
Do. .	(275) Mr. Quah Cheng Guan.	Tin, wolfram and allied minerals.	M. L. .	256	Do. .	30 years.
Do. .	(276) Ma Yai . .	Tin and wolfram	M. L. .	325·9	1st November 1926.	Do.
Do. .	(277) Mr. A. W. Ross	Do. .	M. L. .	162·5	16th January 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*
(*a*) The license was sanctioned on the 7th September 1926.
(*b*) The license was sanctioned on the 26th November 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(278) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Tin	M. L. .	189·4	1st January 1927.	33 years
Do. .	(279) Do. .	Do. . . .	M. L. .	12·8	Do.	3 years.
Do. .	(280) Do. .	Tin and wolfram .	P. L. . (renewal).	185·6	9th August 1925.	6 months.
Do. .	(281) Mr. Wong Chouk	Do. .	P. L. . (renewal).	748·8	12th November 1925.	1 year.
Do. .	(282) Mr. H. Kelly .	Do. .	P. L. . (renewal).	1,651·2	3rd December 1925.	Do.
Do. .	(283) Mr. A. W. Ross .	Do. .	P. L. . (renewal).	256	26th November 1925.	6 months.
Do. .	(284) Mr. W. C. Toms	Do. .	P. L. . (renewal).	345·6	12th December 1925.	1 year.
Do. .	(285) Mr. Mamode Assenjee.	Do. .	P. L. . (renewal).	396 8	15th December 1925.	Do.
Do. .	(286) The Burma Finance and Mining Co., Ltd.	Do. .	P. L. . (renewal).	179·2(*a*)	31st March 1926.	Do.
Do. .	(287) Mr. J. M. Watt .	Do. .	P. L. . (renewal).	198·4(*a*)	20th February 1926.	6 months.
Do. .	(288) Ma Thein May .	Do. .	P. L. . (renewal).	640	17th March 1926.	1 year.
Do. .	(289) Mr. M. A. Musaji	Do. .	P. L. . (renewal).	409·6	30th May 1926.	6 months.
Do. .	(290) Maung Ba Bwa .	Do. .	P. L. . (renewal).	614·4	13th August 1926.	1 year.
Thaton .	(291) Mr. A. C. Martin	All minerals except natural petroleum.	P. L. .	5,120	(*b*)	Do.
Do. .	(292) Saw Lein Lee .	Do. .	P. L. .	640	8th November 1926.	Do.
Do. .	(293) Maung Htay .	Do. .	P. L. . (renewal).	480	22nd September 1926.	Do.
Do. .	(294) Mr. A. Rahim .	Do. .	P. L. . (renewal).	2,257·92	30th November 1926.	Do.
Thayetmyo .	(295) Messrs. The Burma Oil Co., Ltd., Nyaunghla.	Natural petroleum	P. L. .	2,240	23rd March 1926.	2 years.
Do. .	(296) Do. .	Do. .	P. L. .	1,680	8th January 1926.	Do.
Do. .	(297) Messrs. W. R. Smith and Sons, Rangoon.	Do. .	P. L. .	531·2	19th May 1926.	Do.
Do. .	(298) Messrs. The Burma Oil Co., Ltd., Nyaunghla.	Do. .	P. L. .	4,300	3rd June 1926.	Do.
Do. .	(299) Messrs. The Indo-Burma Oil Fields (1920) Ltd., Thayetmyo.	Do. .	P. L. .	640	20th March 1926.	1 year.

P. L. = *Prospecting License.* *M. L.* = *Mining Lease.*

(*a*) Area revised on renewal.

(*b*) The license was sanctioned on the 2nd September 1926.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo	(300) U Tun Aung Gyaw, Thayetmyo.	Natural petroleum	P. L. .	486·4	12th June 1926.	2 years.
Do. .	(301) Messrs. The Indo-Burma Oil Fields (1920) Ltd., Thayetmyo.	Do. .	P. L. (renewal).	633·6	2nd January 1926.	1 year.
Do. .	(302) Ismail Abu Ahmed, Thayetmyo.	Do. .	P. L. (renewal).	2,400	15th January 1926.	Do.
Do. .	(303) Mr. Omar Abu-Bucker, Thayetmyo.	Do. .	P. L. (renewal).	2,560	23rd February 1926.	Do.
Do. .	(304) Messrs. The Indo-Burma Oil Fields (1920) Ltd., Thayetmyo.	Do. .	P. L. (renewal).	960	12th March 1926.	Up to 22nd July 1926.
Do. .	(305) Mr. Colin Campbell, Rangoon.	Mineral oil . .	P. L. (renewal).	1,420·8	11th July 1926.	1 year.
Toungoo .	(306) Capt. E. L. Bill.	All minerals except oil.	P. L. (renewal).	320	22nd February 1926.	Do.
Upper Chindwin.	(307) The Coal Fields of Burma Ltd., Thayetmyo.	Coal . . .	P. L. (renewal).	678·4	3rd March 1926.	Do.
Do. .	(308) Do. .	Do. . . .	P. L. (renewal).	665·6	Do. .	Do.
Do. .	(309) Messrs. The Indo-Burma Petroleum Co., Ltd., Rangoon.	Natural petroleum	P. L. (renewal).	2,560	17th March 1926.	Do.
Do. .	(310) Messrs. The Indo-Burma Oil Fields (1920) Ltd., Thayetmyo.	Do. .	P. L. (renewal).	3,200	11th July 1926.	Do.
Do. .	(311) Messrs. The Burma Oil Co., Ltd.	Do. .	P. L. (renewal).	1,760	28th August 1926.	Do.
Do. .	(312) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. .	P. L. (renewal).	640	6th October 1926.	Do.
Yamethin .	(313) Mr. Colin Campbell of Kalaw.	All minerals except natural petroleum.	P. L. .	620·8	20th September 1926.	Do.

CENTRAL PROVINCES.

Balaghat .	(314) Messrs. B. Fouzdar Brothers.	Mica . . .	M. L. .	15	6th April 1926.	5 years.
Do. .	(315) Do. .	Do. . . .	M. L. .	16	Do. .	Do.
Do. .	(316) Do. .	Do. . . .	M. L. .	20	Do. .	10 years.
Do. .	(317) Seth Jagannath, Tumsar.	Manganese .	M. L. .	73	1st February 1926.	15 years.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(318) Mr. P. N. Oke .	Manganese .	M. L. .	28	8th October 1926.	15 years.
Do. .	(319) Seth Chhogmal Kocher, Narsinghpur.	Do. .	M. L. .	12	5th February 1926.	20 years.
Do. .	(320) Pandit Rewashankar.	Do. .	P. L. .	208	9th July 1926	1 year.
Do. .	(321) Abdul Rahim Khan.	Do. .	P. L. .	94	19th March 1926.	Do.
Do. .	(322) Mr. P. N. Oke .	Do. .	M. L. .	155	13th March 1926.	10 years.
Do. .	(323) Mr. Chandanlal	Do. .	P. L. .	339	2nd February 1926.	1 year.
Do. .	(324) Pandit Rewashankar.	Do. .	P. L. .	42	7th July 1926	Do.
Do. .	(325) Do. .	Do. .	M. L. .	7	5th August 1926.	30 years.
Do. .	(326) Mr. Syed Minhajuddin Ahmed.	Do. .	M. L. .	2	24th September 1926.	Do.
Do. .	(327) Pandit Rewashankar.	Do. .	M. L. .	10	24th November 1926.	Do.
Do. .	(328) Do. .	Do. .	M. L. .	94	Do. .	20 years.
Do. .	(329) R. B. L. Chhajjuram.	Do. .	M. L. .	40	17th March 1926.	5 years.
Do. .	(330) Mr. M. B. Marfatia.	Do. .	P. L. .	118	16th January 1926.	1 year.
Do. .	(331) Mr. Chandanlal	Do. .	P. L. .	6	2nd February 1926.	Do.
Do. .	(332) Mr. Gulam Muhamad.	Do. .	M. L. .	15	16th February 1926.	10 years.
Do. .	(333) Mr. Noor Muhamad Mitha.	Do. .	M. L. .	49	5th February 1926.	20 years.
Do. .	(334) Messrs. Nosharwanji and Ardeshir Brothers.	Do. .	P. L. .	372	14th March 1926.	1 year.
Do. .	(335) Seth Sarupchand Sao.	Do. .	P. L. .	2	24th January 1926.	Do.
Do. .	(336) Seth Paramanand Bansidhar.	Do. .	P. L. .	135	5th January 1926.	Do.
Do. .	(337) Pandit Kripa Shankar.	Do. .	M. L. .	131	15th March 1926.	15 years.
Do. .	(338) Mr. M. B. Marfatia.	Do. .	P. L. .	3	17th January 1926.	1 year.
Do. .	(339) Mr. P. N. Oke .	Do. .	M. L. .	14	8th October 1926.	10 years.
Do. .	(340) Messrs. Martin & Co.	Do. .	M. L. .	150	13th July 1926.	30 years.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(341) Seth Bhudar Sao.	Manganese .	P. L. .	11	4th January 1926.	1 year.
Do. .	(342) Messrs. Ramnath Baijnath, Rasia.	Do. .	P. L. .	460	24th January 1926.	Do.
Do. .	(343) Mr. M. B. Marfatia.	Do. .	P. L. .	71	16th January 1926.	Do.
Do. .	(344) Seth Chhogmal, Kocher.	Do. .	M. L. .	15	12th June 1926.	5 years.
Do. .	(345) Mr. Amrit Lal P. Trivedi.	Do. .	P. L. .	152	16th January 1926.	1 year.
Do. .	(346) Seth Bhudar Sao	Do. .	P. L. .	402	20th April 1926.	Do.
Do. .	(347) Mr. Amrit Lal P. Trivedi.	Do. .	P. L. .	76	16th January 1926.	Do.
Do. .	(348) Mr. Sundarlal Golchha.	Do. .	P. L. .	88	25th April 1926.	Do.
Do. .	(349) Mr. P. N. Oke .	Do. .	P. L. .	35	5th February 1926.	Do.
Do. .	(350) Seth Sarupchand Sao.	Do. .	P. L. .	73	24th January 1926.	Do.
Do. .	(351) Mr. Amrit Lal P. Trivedi.	Do. .	P. L. .	259	14th February 1926.	Do.
Do. .	(352) Messrs. Ramnath and Baijnath Sao.	Do. .	P. L. .	15	4th January 1926.	Do.
Do. .	(353) Do. .	Do. .	P. L. .	14	Do. .	Do.
Do. .	(354) Mr. Amrit Lal P. Trivedi.	Do. .	P. L. .	220	29th January 1926.	Do.
Do. .	(355) Mr. Seth Parmanand Bansidhar.	Do. .	P. L. .	1	24th January 1926.	Do.
Do. .	(356) Do. .	Do. .	P. L. .	6	5th January 1926.	Do.
Do. .	(357) Seth Jagannath	Do. .	M. L. .	17	17th May 1926.	Till 1st January 1941.
Do. .	(358) Seth Pratab Laxman Ram.	Do. .	P. L. .	27	14th March 1926.	1 year.
Do. .	(359) Thakur Nasib Singh.	Do. .	P. L. .	128	5th February 1926.	Do.
Do. .	(360) Musstt. Munna Bai.	Do. .	P. L. .	6	10th January 1926.	Do.
Do. .	(361) Messrs. Ganpat Sao Dhanpat Sao.	Do. .	P. L. .	7	20th March 1926.	Do.
Do. .	(362) Messrs. Samrathmal and Ratanchand.	Do. .	P. L. .	103	8th August 1926.	Do.
Do. .	(363) Mr. M. B. Marfatia.	Do. .	P. L. .	46	19th March 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(364) Messrs. B. P. Byramji & Co.	Manganese .	M. L. .	43	8th March 1926.	5 years.
Do. .	(365) Seth Bhudar Sao.	Do. . .	P. L. .	54	2nd February 1926.	1 year.
Do. .	(366) Thakur Nasib Singh.	Do. . .	P. L. .	7	5th February 1926.	Do.
Do. .	(367) Mr. C. S. Harris	Do. . .	P. L. .	25	2nd February 1926.	Do.
Do. .	(368) Mr. M. B. Marfatia.	Do. . .	P. L. .	117	3rd February 1926.	Do.
Do. .	(369) Do. .	Do. . .	P. L. .	26	2nd February 1926.	Do.
Do. .	(370) Messrs. Nilkant Sao & Co.	Do. . .	P. L. .	77	14th March 1926.	Do.
Do. .	(371) Do. .	Do. . .	P. L. .	44	19th March 1926.	Do.
Do. .	(372) Mr. Shamji Narainji.	Do. . .	P. L. .	17	4th March 1926.	Do.
Do. .	(373) Do. .	Do. . .	P. L. .	49	25th March 1926.	Do.
Do. .	(374) Mr. A. H. Mohmad Suleman.	Do. . .	P. L. .	2	3rd July 1926.	Do.
Do. .	(375) Thakur Nasib Singh.	Do. . .	P. L. .	6	25th March 1926.	Do.
Do. .	(376) Do. .	Do. . .	P. L. .	36	24th March 1926.	Do.
Do. .	(377) Messrs. Amrit Lal and P. Trivedi.	Do. . .	P. L. .	72	20th March 1926.	Do.
Do. .	(378) Messrs. Nosherwanji and Ardeshir Brothers.	Do. . .	P. L. .	1	13th May 1926.	Do.
Do. .	(379) Mr. Kanhaiyalal	Do. . .	P. L. .	49	26th February 1926.	Do.
Do. .	(380) Messrs. Amrit Lal and P. Trivedi.	Do. . .	P. L. .	179	9th April 1926.	Do.
Do. .	(381) Thakur Nasib Singh.	Do. . .	P. L. .	70	25th May 1926.	Do.
Do. .	(382) Messrs. Chotan and Premlal.	Do. . .	P. L. .	7	26th August 1926.	Do.
Do. .	(383) Rai Sahib A. P. Bhargava.	Do. . .	P. L. .	150	19th February 1926.	Do.
Do. .	(384) Mr. Amrit Lal and Pandit Trivedi.	Do. . .	P. L. .	11	14th March 1926.	Do.
Do. .	(385) Do. .	Do. . .	P. L. .	462	19th March 1926.	Do.
Do. .	(386) Musstt. Munna Bai.	Do. . .	P. L. .	195	3rd May 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(387) Rao Bahadur Chhajjoo Ram.	Manganese .	P. L. .	113	24th July 1926.	1 year.
Do. .	(388) Do. .	Do. . .	P. L. .	21	9th June 1926.	Do.
Do. .	(389) Musstt. Munna Bai.	Do. . .	P. L. .	150	8th April 1926.	Do.
Do. .	(390) Mr. Sunderlal Golchha.	Do. . .	P. L. .	136	8th December 1926.	Do.
Do. .	(391) Musstt. Munna Bai.	Do. . .	P. L. .	328	17th April 1926.	Do.
Do. .	(392) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	137	14th March 1926.	Do.
Do. .	(393) Mr. Chandan Lal	Do. . .	P. L. .	21	7th March 1926.	Do.
Do. .	(394) The Central India Mining Company.	Do. . .	P. L. .	284	28th May 1926.	Do.
Do. .	(395) Musstt. Munna Bai.	Do. . .	P. L. .	4	17th April 1926.	Do.
Do. .	(396) Messrs. Ramnath and Baijnath, Rasia.	Do. . .	P. L. .	67	25th April 1926.	Do.
Do. .	(397) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	73	30th July 1926.	Do.
Do. .	(398) Messrs. Bakhtawar Singh Kunjilal.	Do. . .	P. L. .	23	25th June 1926.	Do.
Do. .	(399) Mr. M. B. Marfatia.	Do. . .	M. L. .	14	26th April 1926.	3 years.
Do. .	(400) Mr. Chandanlal .	Do. . .	P. L.	91	20th November 1926.	1 year.
Do. .	(401) Messrs. B. P. Byramji & Co.	Do. . .	P. L. .	32	10th June 1926.	Do.
Do. .	(402) Do. .	Do. . .	P. L. .	7	Do. .	Do.
Do. .	(403) Do. .	Do. . .	P. L. .	74	Do. .	Do.
Do. .	(404) Mr. Kanhaiyalal	Do. . .	P. L. .	60	7th October 1926.	Do.
Do. .	(405) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	27	10th July 1926.	Do.
Do. .	(406) Messrs. Lalbehari Ramcharan.	Do. . .	M. L. .	6	Do. .	5 years.
Do. .	(407) Do. .	Do. . .	M. L. .	5	Do. .	Do.
Do. .	(408) Mr. M. B. Marfatia.	Do. . .	M. L. .	24	31st May 1926.	Do.
Do. .	(409) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	121	9th June 1926.	1 year.
Do. .	(410) Mr. M. B. Marfatia.	Do. . .	M. L. (Supplementary). .	2	17th July 1926.	Till 25th April 1929.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(411) Mr. M. B. Marfatia.	Manganese .	M. L. .	27	14th July 1926.	30 years.
Do. .	(412) Messrs. Gangaram and Bithoba Kirads.	Do. . .	P. L. .	9	7th July 1926.	1 year.
Do. .	(413) Pandit Kripashankar.	Do. . .	P. L. .	136	14th July 1926.	Do.
Do. .	(414) Messrs. Nagarmal Amolakchand and Jiwraj Poddar.	Do. . .	P. L. .	345	22nd September 1926.	Do.
Do. .	(415) Thakur Nasib Singh.	Do. . .	P. L. .	105	2nd August 1926.	Do.
Do. .	(416) Mr. Amrit Lal P. Trivedi.	Do. . .	M. L. .	85	8th October 1926.	30 years.
Do. .	(417) Mr. Kanhaiyalal	Do. . .	P. L. .		25th September 1926.	1 year.
Do. .	(418) Mr. Bhawanji Naranji.	Do. . .	P. L. .	321	7th September 1926.	Do.
Do. .	(419) Mr. Chandanlal .	Do. . .	P. L. .	45	15th December 1926.	Do.
Do. .	(420) Do. .	Do. . .	P. L. .	127	19th November 1926.	Do.
Do. .	(421) Thakur Nasib Singh.	Do. . .	P. L. .	451	9th November 1926.	Do.
Do. .	(422) Messrs. Nilkant Sao & Co.	Do. . .	P. L. .	41	12th October 1926.	Do.
Do. .	(423) Mr. M. B. Marfatia.	Do. . .	P. L. .	37	24th September 1926.	Do.
Do. .	(424) Musstt. Munna Bai.	Do. . .	P. L. .	51	6th August 1926.	Do.
Do. .	(425) Messrs. Gangaram & Vithoba.	Do. . .	P. L. .	194	10th August 1926.	Do.
Do. .	(426) Do. .	Do. . .	P. L. .	106	Do. .	Do.
Do. .	(427) Mr. Samiulla Khan.	Do. . .	P. L. .		1st December 1926.	Do.
Do. .	(428) Mr. M. B. Marfatia.	Do. . .	P. L. .	99	25th September 1926.	Do.
Do. .	(429) Seth Bhupat Rao	Do. . .	P. L. .	86	14th July 1926.	Do.
Do. .	(430) Pandit Kripasankar.	Do. . .	P. L. .	104	26th August 1926.	Do.
Do. .	(431) Do. .	Do. . .	P. L. .	65	18th September 1926.	Do.
Do. .	(432) Do. .	Do. . .	P. L. .	19	Do. .	Do.
Do. .	(433) Musstt. Munna Bai.	Do. . .	P. L. .	617	8th October 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(434) Mr. Amrit Lal P. Trivedi.	Manganese .	P. L. .	211	30th July 1926.	1 year.
Do. .	(435) Do. .	Do. . .	M. L. .	41	13th December 1926.	5 years.
Do. .	(436) Seth Kisandayal Gopal Labhuchand.	Do. . .	P. L. .	14	20th August 1926.	1 year.
Do. .	(437) Thakur Nasib Singh.	Do. . .	M. L. .	7	17th November 1926.	5 years.
Do. .	(438) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	34	30th July 1926.	1 year.
Do. .	(439) Messrs. Nilkant Sao & Co.	Do. . .	P. L. .	79	12th October 1926.	Do.
Do. .	(440) Mr. Kanhaiyalal	Do. . .	P. L. .	125	25th September 1926.	Do.
Do. .	(441) Nawab Meazuddin Khan.	Do. . .	P. L. .	183	24th October 1926.	Do.
Do. .	(442) Seth Bhudar Sao.	Do. . .	P. L. .	22	6th December 1926.	Do.
Do. .	(443) Do. .	Do. . .	P. L. .	58	18th September 1926.	Do.
Do. .	(444) Mr. C. S. Harris.	Do. . .	P. L. .	43	3rd September 1926.	Do.
Do. .	(445) Lala Baijnath Kalar.	Do. . .	P. L. .	493	18th September 1926.	Do.
Do. .	(446) Messrs. Nilkant Sao & Co.	Do. . .	P. L. .	11	12th October 1926.	Do.
Do. .	(447) Mr. Kanhaiyalal.	Do. . .	P. L. .	21	7th October 1926.	Do.
Do. .	(448) Do. .	Do. . .	P. L. .	59	Do. .	Do.
Do. .	(449) Mr. C. S. Harris.	Do. . .	P. L. .	2	7th September 1926.	Do.
Do. .	(450) Thakur Nasib Singh.	Do. . .	P. L. .	379	9th November 1926.	Do.
Do. .	(451) Mr. M. B. Marfatia.	Do. . .	P. L. .	45	25th September 1926.	Do.
Do. .	(452) Do. .	Do. . .	P. L. .	63	12th October 1926.	Do.
Do. .	(453) Do. .	Do. . .	P. L. .	16	23rd December 1926.	Do.
Do. .	(454) Do. .	Do. . .	P. L. .	38	12th October 1926.	Do.
Do. .	(455) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	61	22nd September 1926.	Do.
Do. .	(456) Musstt. Munna Bai.	Do. . .	P. L. .	12	22nd December 1926.	Do.
Do. .	(457) Mr. Amrit Lal P. Trivedi.	Do. . .	P. L. .	56	19th November 1926.	Do

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(458) Mr. Amrit Lal P. Trivedi.	Manganese	P. L.	67	19th November 1926.	1 year.
Do.	(459) R. B. Chhajjoram	Do.	P. L.	213	4th December 1926.	Do.
Do.	(460) Pandit Kripashankar.	Do.	M. L.	126	13th December 1926.	30 years.
Bhandara	(461) Messrs. N. D. Zall and Brothers.	Do.	P. L.	13	27th January 1926.	1 year.
Do.	(462) M. Wasudeo Shrawanji, Dalal.	Do	P. L.	42	12th April 1926.	Do.
Do.	(463) Messrs. Yadulal and Bhadulal.	Do.	P. L.	19	6th June 1926.	Do.
Do.	(464) Messrs. Ganpatsao and Dhanpatsao.	Do.	P. L.	60	11th January 1926.	Do.
Do.	(465) Mr. P. N. Oke	Do.	P. L.	266	4th February 1926.	Do.
Do.	(466) R. S. Seth Gowardhandas.	Do.	P. L.	7	26th December 1925.	Do.
Do.	(467) Messrs. Nilkant Sao & Co.	Do.	P. L.	85	18th October 1926.	Do.
Do.	(468) Messrs. Namdeo Pandurang Dalal and Others.	Do.	P. L.	13	5th March 1926.	Do.
Do.	(469) Messrs. Ganpatsao and Dhanpatsao.	Do.	P. L.	14	11th January 1926.	Do.
Do.	(470) Do.	Do.	P. L.	13	Do.	Do.
Do.	(471) Rao Sahib Seth Gowardhandas.	Corundum	P. L.	41	19th February 1926.	Do.
Do.	(472) Mr. M. A. Pasha, Minor.	Manganese	P. L.	282	3rd March 1926.	Do.
Bandara	(473) Mr. Samiulla Khan.	Do.	P. L.	325	4th February 1926.	Do.
Do.	(474) Rai Bahadur Bansilal Abhirchand, Mining Syndicate.	Do.	P. L.	53	19th July 1926.	Do.
Do.	(475) Mr. M. A. Pasha, Minor.	Do.	P. L.	84	3rd March 1926.	Do.
Do.	(476) Mr. A. C. Moitra	Do.	P. L.	152	5th June 1926.	Do.
Do.	(477) Seth Ganeshlal and Balbhadra.	Do.	P. L.	8	23rd April 1926.	Do.
Do.	(478) Mr. Mangal Singh.	Do.	P. L.	19	15th February 1926.	Do.
Do.	(479) Messrs. Nilkant Sao & Co.	Do.	P. L.	88	30th April 1926.	Do.
Do.	(480) Messrs. Nowroji Rustomji and M. Chakrabarti.	Do.	P. L.	115	29th September 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bandara	(481) Mr Shriram Seth.	Manganese	P. L.	117	22nd April 1926.	1 year.
Do.	(482) The Central India Mining Company, Limited.	Do.	P. L.	293	22nd May 1926.	Do.
Do.	(483) Mr. M. A. Pasha, Minor.	Do.	P. L.	69	4th December 1926.	Do.
Do.	(484) Mr. A. C. Moitra	Do.	P. L.	324	26th June 1926.	Do.
Do.	(485) Messrs. Ganpatsao and Dhanpatsa.	Do.	P. L. (Renewal).	151	16th March 1926.	Do.
Do.	(486) Messrs. Gangaram and Bithoba.	Do.	P. L.	16	25th June 1926.	Do.
Do.	(487) Nawab Neazuddin Khan.	Do.	P. L.	141	20th October 1926.	Do.
Do.	(488) Do.	Do.	P. L.	43	28th September 1926.	Do.
Do.	(489) Do.	Do.	P. L.	78	Do.	Do.
Do.	(490) Do.	Do.	P. L.	87	Do.	Do.
Do.	(491) Messrs. Kisandayal Gopal and Labhuchand Narsinghdas.	Do.	P. L.	135	11th August 1926.	Do.
Do.	(492) Messrs. Muralidhar and Bhudulal.	Do.	P. L.	365	15th October 1926.	Do.
Do.	(493) Messrs. Nilkant Sao & Co.	Do.	P. L. (Renewal).	59	3rd October 1926.	Do.
Do.	(494) Mr. M. A. Pasha, Minor.	Do.	P. L.	278	4th December 1926.	Do.
Do.	(495) Messrs. Ram Chandra Patel and Company.	Do.	P. L.	56	23rd November 1926.	Do.
Do.	(496) R. B. Nritya Gopal Bose.	Do.	P. L.	130	13th November 1926.	Do.
Do.	(497) Mr. M. A. Pasha, Minor.	Do.	M. L.	29	8th June 1926.	15 years.
Do.	(498) Mr. Ghulam Mohamad, B.A.	Do.	M. L.	172	16th February 1926.	10 years.
Do.	(499) Rao Bahadur, B.A., Mining Syndicate.	Do.	M. L.	2	10th July 1926.	15 years.
Do.	(500) R. S. Seth Gowardhandas.	Do.	M. L.	7	15th January 1926.	10 years
Do.	(501) Messrs. Yadulal and Bhudulal.	Do.	M. L.	66	22nd January 1926.	5 years.
Do.	(502) Mr. S. Rangaya Naidu.	Do.	M. L.	34	25th January 1926.	25 years.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bandara	(503) Messrs. Champalal and Company.	Manganese	M. L.	21	9th August 1926.	10 years.
Do.	(504) Mr. Syed Rasool Papamia.	Do.	M. L.	44	12th August 1926.	5 years.
Do.	(505) Messrs. Yadulal and Bhadulal.	Do.	M. L.	11	30th October 1926.	Do.
Do.	(506) Mr. P. N. Oke	Do.	M. L.	15	17th December 1926.	30 years.
Bilaspur	(507) Nawab Niazuddin Khan.	Do.	P. L.	2	24th June 1926.	1 year.
Do.	(508) Messrs. Agarwala Brothers.	Do.	P. L.	200	16th February 1926.	Do.
Do.	(509) Do.	Mica	P. L.	19	3rd September 1926.	Do.
Do.	(510) Do.	Do.	P. L.	12	10th September 1926.	Do.
Do.	(511) Jairam Valji	Coal	P. L.	186	3rd March 1926.	Do.
Do.	(512) Messrs. Dunlop & Co., Considine, Ltd.	Do.	P. L.	12,256	4th September 1926.	Up to June 30th, 1926.
Do.	(513) Do.	Do.	P. L.	3,376	30th November 1926.	Up to 5th November 1927.
Do.	(514) Do.	Do.	P. L.	4,324	Do.	1 year.
Do.	(515) Do.	Coal and iron	P. L.	11,900	9th March 1926. / 8th December 1926.	Up to 8th March 1927.
Do.	(516) Do.	Limestone	P. L.	119	1st December 1926.	1 year.
Chanda	(517) Messrs. Vadilal and Company, Bombay.	Manganese	M. L.	1,016	24th December 1925.	15 months.
Chhindwara	(518) R. S. H. L. Verma and Mr. Kanhaiyala of Chhindwara.	Coal	M. L.	254	12th August 1926.	30 years.
Do.	(519) Seth Hazarimal Bazaj of Chhindwara.	Do.	M. L.	99	15th January 1926.	Do.
Do.	(520) Do.	Manganese	M. L.	83	Do.	Do.
Do.	(521) Do.	Do.	M. L.	31	Do.	Do.
Do.	(522) Mr. Samiulla Khan of Dhotiwara.	Do.	M. L.	10	2nd January 1926.	Do.
Do.	(523) Mr. J. N. Mazumdar of Naweguon.	Limestone	M. L.	3	6th April 1926.	10 years.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(524) Newton Chickhli Collieries, Parasia.	Coal	M. L. (Supplementary).	286	7th July 1926.	Till 15th November 1952.
Do.	(525) Do.	Do.	M. L.	191	Do.	Do.
Do.	(526) Seth Laxmi Narayan Hardeo of Kamptee.	Manganese	P. L.	183	25th January 1926.	1 year.
Do.	(527) Do.	Do.	P. L.	237	Do.	Do.
Do.	(528) Rao Bahadur D. Laxmi Narayan of Kamptee.	Do.	M. L.	269	11th January 1926.	Do.
Do.	(529) Lala Jainarayan Mohonlal of Nagpur.	Do.	P. L.	28	31st March 1926.	Do.
Do.	(530) Thakur Randhir Shah of Sonpur.	Do.	P. L.	304	24th June 1926.	Do.
Do.	(531) Mr. Husain Khan of Chhindwara.	Do.	P. L.	84	5th March 1926.	Do.
Do.	(532) Subedar Mirtunjai Prasad of Taku.	Coal	P. L.	84	12th October 1926.	Do.
Do.	(533) Do.	Do.	P. L.	279	Do.	Do.
Do.	(534) Mr. Hussain Khan of Chhindwara.	Manganese	P. L.	180	5th March 1926.	Do.
Do.	(535) Do.	Do.	P. L.	248	3rd August 1926.	Do.
Do.	(536) Messrs. Chaitram Sao Tikaram Sao of Chhindwara.	Do.	P. L.	676	9th March 1926.	Do.
Do.	(537) Mr. Hussain Khan of Chhindwara.	Do.	P. L.	85	19th March 1926.	Do.
Do.	(538) Messrs. Chaitram Sao Tikaram Sao of Chhindwara.	Do.	P. L.	290	9th March 1926.	Do.
Do.	(539) Seth Kishandayal Gopal Labhuchand of Kamptee.	Do.	P. L.	58	14th August 1926.	Do.
Do.	(540) Mr. A. V. Wazalwar, Nagpur.	Do.	P. L.	57	11th December 1926.	Do.
Do.	(541) Mr. Hussain Khan of Chhindwara.	Do.	P. L.	60	26th April 1926.	Do.
Do.	(542) Do.	Graphite	P. L.	168	3rd August 1926.	Do.
Do.	(543) Mr. Samiulla Khan, Dhotiwara.	Manganese	P. L.	67	Do.	Do.
Do.	(544) Messrs. Chaitram Sao Tikaram Sao of Chhindwara.	Do.	P. L.	81	28th July 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(545) Mr. Pratul Narayan Mukerji, Parasia.	Coal . . .	P. L. .	331	19th November 1926.	1 year.
Do. .	(546) Messrs. Chaitram Sao Tikaram Sao, Chhindwara.	Manganese . .	P. L. .	152	26th November 1926.	Do.
Do. .	(547) Mr. Hussain Khan, Chhindwara.	Do. . .	P. L. .	167	4th December 1926.	Do.
Do. .	(548) Do. .	Do. . .	P. L. .	126	13th October 1926.	Do.
Do. .	(549) Do. .	Manganese and pyrites.	P. L. .	45	4th August 1926.	Do.
Do. .	(550) R. S. Minamal Nandlal, Chhindwara.	Coal . . .	P. L. .	307	3rd July 1926.	Do.
Do. .	(551) Mr. Samiulla Khan, Dhotiwara.	Manganese . .	P. L. .	131	26th August 1926.	Do.
Do. .	(552) Mr. Aminuddin of Nagpur.	Do. . .	P. L. .	199	21st December 1926.	Do.
Jubbulpore	(553) Mr. Sundarlal Golcha, B.A.	Bauxite . .	P. L. .	52	2nd March 1926.	Do.
Do. .	(554) Messrs. Sukhdeo Prosad Radha Krishna.	Manganese . .	P. L. .	94	16th April 1926.	Do.
Do. .	(555) Mr. N. Venkat Ramanna.	Do. . .	P. L. .	192	5th January 1926.	Do.
Do. .	(556) Messrs. Ganpat Sao Dhanpat Sao.	Do. . .	P. L. .	205	29th July 1926.	Do.
Do. .	(557) Messrs. Sukhdeo Prosad Radha Krishna.	Do. . .	P. L. .	29	9th July 1926.	Do.
Do. .	(558) Mr. M. B. Marfatia.	Do. . .	P. L. .	69	11th January 1926.	Do.
Do. .	(559) Mr. Nosherwanji Ardeshir.	Do. . .	P. L. .	228	9th February 1926.	Do.
Do. .	(560) Seth Laxmi Narayan Hardeo.	Do. . .	M. L. .	16	24th June 1926.	10 years.
Do. .	(561) Messrs. Gupta & Sons.	Do. . .	M. L. .	5	7th July 1926.	5 years.
Do. .	(562) Mr. P. C. Bose	Do. . .	P. L. .	37	8th February 1926.	1 year.
Do. .	(563) Messrs. Ganpat Sao Dhanpot Sao.	Do. . .	P. L. .	74	24th June 1926.	Do.
Do. .	(564) Messrs. Ganpat Rao Laxman Rao.	Do. . .	M. L. .	16	12th April 1926.	30 years.
Do. .	(565) Mr. Stanley Harris.	Do. . .	P. L. .	340	10th May 1926.	1 year.
Do. .	(566) Beohar Gulab Singh.	Do. . .	P. L. .	371	16th April 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(567) Messrs. Ganpat Sao Dhanpat Sao.	Manganese	P. L.	52	24th June 1926.	1 year.
Do.	(568) Do.	Do.	P. L.	23	Do.	Do.
Do.	(569) Do.	Do.	P. L.	28	Do.	Do.
Do.	(570) Mr. A. W. Durby	Do.	P. L.	488	8th September 1926.	Do.
Do.	(571) Messrs. Mac Pherson & Co.	Bauxite	P. L.	567	13th December 1926.	Do.
Do.	(572) The Central Provinces Mining Company, Ltd.	Do.	P. L.	20	19th June 1926.	Do.
Do.	(573) Do.	Manganese	P. L.	95	Do.	Do.
Do.	(574) Mr. Chhakori Lall Pathak.	Bauxite	P. L.	43	22nd November 1926.	Do.
Nagpur	(575) Mr. M. A. Razaq, Kamptee.	Manganese	P. L.	92	6th February 1926.	Do.
Do.	(576) Mr. Dwarkanath, Delhi.	Do.	M. L.	160	7th January 1926.	30 years.
Do.	(577) Seth Raghunath Das, Kamptee.	Do.	M. L.	21	15th June 1926.	15 years.
Do.	(578) Mr. Akbarali Manwarali, Nagpur.	Do.	P. L.	134	31st August 1926.	1 year.
Do.	(579) Mr. Goswami, Moheshpuri, Nagpur.	Do.	M. L.	12	5th July 1926.	10 years.
Do.	(580) Mr. M. A. Razaq, Kamptee.	Do.	M. L.	12	4th June 1926.	3 years.
Do.	(581) The Central India Mining Company, Ltd.	Do.	P. L.	102	11th March 1926.	1 year.
Do.	(582) Seth Laxminarayan Hardeo, Kamptee.	Do.	M. L.	2	20th March 1926.	2 years.
Do.	(583) Messrs. Fouzdar Brothers, Nagpur.	Do.	P. L.	222	26th March 1926.	1 year.
Do.	(584) Mr. Dwarkanath, Delhi.	Do.	M. L.	96	3rd April 1926.	5 years.
Do.	(585) Mr. Moheshpuri Nagpur.	Do.	M. L.	11	29th May 1926.	7 years and 6½ months.
Do.	(586) R. S. Gowardhan Dass, Tumsar.	Do.	M. L.	163	29th March 1926.	30 years.
Do.	(587) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do.	P. L.	300	11th January 1926.	1 year.
Do.	(588) Mr. Ganpat Rao Laxman Rao, Nagpur.	Limestone	Q. L.	4	11th January 1926.	10 years.

P. L. = Prospecting License. *M. L. = Mining Lease.* *Q. L. = Quarry Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(589) Seth Raghunath Das Bharuka, Kamptee.	Manganese . .	M. L. .	35	15th June 1926.	15 years.
Do. .	(590) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do. . .	P. L. .	136	26th February 1926.	1 year.
Do. .	(591) Mr. A. H. Ahmed	Limestone . .	Q. L. .	51	10th June 1926.	10 years.
Do. .	(592) Mr. Shamji Narainji, Ramtek.	Manganese . .	M. L. .	30	22nd May 1926.	Do.
Do. .	(593) Mr. M. A. Razak, Kamptee.	Do. . .	P. L. .	21	14th June 1926.	1 year.
Do. .	(594) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do. . .	P. L. .	88	26th February 1926.	Do.
Do. .	(595) Mr. M. A. Razaq, Kamptee.	Do. . .	P. L. .	103	16th January 1926.	Do.
Do. .	(596) Mr. Moheshpuri, Nagpur.	Do. . .	P. L. .	45	26th June 1926.	Do.
Do. .	(597) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	100	23rd January 1926.	Do.
Do. .	(598) Do. .	Do. . .	P. L. .	95	Do. .	Do.
Do. .	(599) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do. . .	P. L. .	66	22nd January 1926.	Do
Do .	(600) Mr. Moheshpuri, Nagpur.	Do. . .	P. L. .	156	16th January 1926.	Do.
Do. .	(601) Do. .	Do. . .	P. L. .	59	Do. .	Do.
Do. .	(602) Seth Raghunath Das, Bharuka.	Do. . .	P. L. .	115	25th June 1926.	Do.
Do. .	(603) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do. . .	P. L. .	192	9th July 1926.	Do.
Do. .	(604) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do. . .	P. L. .	144	16th February 1926.	Do.
Do. .	(605) Mr. S. Aminuddin, Nagpur.	Do. . .	P. L. .	55	17th March 1926.	Do.
Do. .	(606) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	44	23rd January 1926.	Do.
Do. .	(607) Mr. S. Aminuddin, Nagpur.	Do. . .	P. L. .	9	26th June 1926.	Do.
Do. .	(608) Dr. B. D. Vyas, Kamptee.	Do. . .	P. L. .	38	20th August 1926.	Do.
Do. .	(609) Mr. P. C. Dutt, Nagpur.	Do. . .	P. L. .	453	27th January 1926.	Do.
Do. .	(610) Do. .	Do. . .	M. L. .	320	31st March 1926.	30 years.

P. L. = Prospecting License. *Q. L. = Quarry Lease.* *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(611) Mr. Shamji Narainji, Ramtek.	Manganese .	M. L. .	15	25th February 1926.	30 years.
Do. .	(612) Messrs. Gupta & Sons, Nagpur.	Do. . .	M. L. .	536	20th October 1926.	Do.
Do. .	(613) Mr. M. A. Razak, Kamptee.	Do. . .	M. L. .	124	14th June 1926.	Do.
Do. .	(614) Mr. S. Aminuddin, Nagpur.	Do. . .	P. L. .	133	17th March 1926.	1 year.
Do. .	(615) Do. .	Do. . .	P. L. .	39	4th January 1926.	Do.
Do. .	(616) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	30	25th February 1926.	Do.
Do. .	(617) Messrs. N. Rostomji and M. Chakrabarty, Nagpur.	Do. . .	P. L. .	38	19th February 1926.	Do.
Do. .	(618) Do. .	Do. . .	P. L. .	56	Do. .	Do.
Do. .	(619) Messrs. N. Rustomji and M. Chakrabarty.	Do. . .	P. L. .	96	16th June 1926.	Do.
Do. .	(620) Mr. S. Aminuddin, Nagpur.	Do. . .	P. L. .	7	17th March 1926.	Do.
Do. .	(621) Do. .	Do. . .	P. L. .	12	Do. .	Do.
Do. .	(622) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	139	25th February 1926.	Do.
Do. .	(623) Mr. P. C. Dutt, Nagpur.	Do. . .	P. L. .	215	4th August 1926.	Do.
Do. .	(624) Mr. Akbarali Manwarali, Nagpur.	Do. . .	P. L. .	118	31st August 1926.	Do.
Do. .	(625) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	20	25th February 1926.	Do.
Do. .	(626) The Berar Mining Association, Nagpur.	Do. . .	P. L. .	30	3rd December 1926.	Do.
Do. .	(627) The Indian Mining Company, Ltd., Nagpur.	Do. . .	P. L. .	74	16th June 1926.	Do.
Do. .	(628) The Berar Mining Association, Nagpur.	Do. . .	P. L. .	331	19th June 1926.	Do.
Do. .	(629) Mr. Shamji Narainji, Ramtek.	Do. .	P. L. .	57	14th October 1926.	Do.
Do. .	(630) Messrs. Hariram and Maniram Heora, Ramtek.	Do. .	M. L. .	4	28th August 1926.	3 years.
Do. .	(631) Mr. Moheshpuri, Nagpur.	Do. .	M. L. .	81	17th September 1926.	10 years.
Do. .	(632) Messrs. Gupta & Sons, Nagpur.	Do. . .	P. L. .	68	9th July 1926.	1 year.

P. L. = Prospecting License. *M. L. = Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(633) Mr. Shamji Narainji, Ramtek.	Manganese	M. L.	12	10th March 1926.	10 years.
Do.	(634) Do.	Do.	M. L.	17	Do.	Do.
Do.	(635) Do.	Do.	M. L.	26	Do.	Do.
Do.	(636) Messrs. Ganpat Sao Dhanpat Sao, Andhargaon.	Do.	M. L.	19	15th June 1926.	20 years.
Do.	(637) Mr. Shamji Narainji, Ramtek.	Do.	M. L. (Supplementary).	5	24th April 1926.	Will expire along with original lease.
Do.	(638) Do.	Do.	M. L. (Supplementary).	3	10th April 1926.	Do.
Do.	(639) Moulana M. E. R. Malak, Nagpur.	Clay	Q. L.	29	18th August 1926.	2 years.
Do.	(640) Mr. K. N. Padhe, Nagpur.	Limestone	Q. L.	11	30th June 1926.	10 years.
Do.	(641) Messrs. Gupta & Sons, Nagpur.	Manganese	M. L.	12	10th April 1926.	30 years.
Do.	(642) R. B. D. Laxminarain, Kamptee.	Do.	M. L.	56	26th October 1926.	4 years.
Do.	(643) Seth Raghunath Das Bharuka, Kamptee.	Do.	M. L.	12	29th July 1926.	5 years.
Do.	(644) Mr. Moheshpuri, Nagpur.	Do.	M. L.	43	12th April 1926.	10 years.
Do.	(645) Messrs. B. Fouzdar Brothers, Nagpur.	Do.	M. L.	13	23rd October 1926.	30 years.
Do.	(646) Messrs. Ganpat Sao Dhanpat Sao.	Do.	P. L.	66	22nd September 1926.	1 year.
Do.	(647) Mr. Shamji Narainji, Ramtek.	Do.	P. L.	40	10th July 1926.	Do.
Do.	(648) The Berar Mining Association, Nagpur.	Do.	P. L.	309	3rd December 1926.	Do.
Do.	(649) Messrs. Nilkanth Sao and Company, Bhandara.	Do.	P. L.	66	17th August 1926.	Do.
Do.	(650) Mr. M. A. Razaq, Kamptee.	Do.	P. L.	22	14th June 1926.	Do.
Do.	(651) Seth Kishandayal Labhuchand, Kamptee.	Do.	P. L.	27	26th June 1926.	Do.
Do.	(652) Mr. M. A. Razak, Kamptee.	Do.	P. L.	60	12th August 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.* *Q. L. = Quarry Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(653) Mr. Bhawanji Narainji, Ramtek.	Manganese . .	P. L. .	25	15th October 1926.	1 year.
Do. .	(654) Mr. Shamji Narainji, Ramtek.	Do. . .	P. L. .	90	9th July 1926.	Do.
Do. .	(655) Mr. Bhawanji Narainji, Ramtek.	Do. . .	P. L. .	54	23rd November 1926.	Do.
Do. .	(656) Do. .	Do. . .	P. L. .	228	10th July 1926.	Do.
Do. .	(657) Do. .	Do. . .	P. L. .	58	23rd November 1926.	Do.
Do. .	(658) Nawab Neazuddin Khan.	Do. . .	P. L. .	42	19th September 1926.	Do.
Do. .	(659) Seth Jamnadas Potdar, Nagpur.	Do. . .	P. L. .	79	23rd January 1926.	Do.
Do. .	(660) Mr. Bhawanji Narainji, Ramtek.	Do. . .	P. L. .	28	10th July 1926.	Do.
Do. .	(661) Do. .	Do. . .	P. L. .	62	3rd September 1926.	Do.
Do. .	(662) Mr. Mohonlal Bridichand, Kamptee	Do. . .	P. L. .	108	3rd September 1926.	Do.
Do. .	(663) The Berar Mining Association, Nagpur.	Do. . .	P. L. .	240	3rd December 1926.	Do.
Do. .	(664) Messrs. Bholanath Das & Company, Calcutta.	Do. . .	P. L. .	38	27th July 1926.	Do.
Do. .	(665) Mr. S. Vinayakrao, Nagpur.	Do. . .	P. L. .	429	23rd November 1926.	Do.
Do. .	(666) Mr. G. R. Totade, Ramtek.	Do. . .	P. L. .	142	19th September 1926.	Do.
Do. .	(667) Khan Saheb Muhmad Yakub of Kamptee.	Do. . .	P. L. .	52	13th October 1926.	Do.
Do. .	(668) Seth Kisandayal and Labhuchand, Kamptee.	Do. . .	P. L. .	33	29th October 1926.	Do.
Do. .	(669) Nawab Neazuddin Khan, Nagpur.	Do. . .	P. L. .	243	30th September 1926.	Do.
Do. .	(670) Do. .	Do. . .	P. L. .	56	8th September 1926.	Do.
Do. .	(671) Do. .	Do. . .	P. L. .	23	Do. .	Do.
Do. .	(672) Mr. Bhowanji Narainji, Ramtek.	Do. . .	P. L. .	46	3rd December 1926.	Do.
Do. .	(673) Seth Kishandayal and Labhuchand, Kamptee.	Do. . .	P. L. .	96	18th November 1926.	Do.
Do. .	(674) Seth Ramkrishna Ramnath, Kamptee.	Do. . .	P. L. .	148	15th December 1926.	Do.

P. L. = Prospecting License.

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(675) Seth Kishandayal Labhuchand, Kamptee.	Manganese . .	P. L. .	128	23rd November 1926.	1 year.
Do. .	(676) Messrs. N. Rustomji and M. Chakrabarty, Nagpur.	Do. . .	P. L. .	238	24th November 1926.	Do.
Do. .	(677) Seth Ramkrishna Ramnath, Kamptee.	Do. . .	P. L. .	320	28th October 1926.	Do.
Do. .	(678) Do. .	Do. . .	P. L. .	110	27th August 1926.	Do.
Do. .	(679) Mr. K. C. Gupta, Nagpur.	Do. . .	P. L. .	357	12th October 1926.	Do.
Do. .	(680) Messrs. N. Rustomji and M. Chakrabarty, Nagpur.	Do. . .	P. L. .	29	24th November 1926.	Do.
Do. .	(681) Mr. K. C. Gupta, Nagpur.	Do. . .	P. L. .	216	3rd December 1926.	Do.
Do. .	(682) Mr. Bhawanji Narainji, Ramtek.	Do. . .	P. L. .	83	14th October 1926.	Do.
Do. .	(683) Mr. M. A. Razaq, Kamptee.	Do. . .	P. L. .	21	23rd November 1926.	Do.
Do. .	(684) Mr. Moheshpuri, Nagpur.	Do. . .	P. L. .	1	8th December 1926.	Do.
Do. .	(685) Sir M. B. Dadabhoy, Nagpur.	Do. . .	M. L. .	2	4th June 1926.	5 years.
Do. .	(686) Mr. Moheshpuri, Nagpur.	Do. . .	M. L. .	11	22nd November 1926.	10 years.
Do. .	(687) Do. .	Do. . .	M. L. .	120	16th December 1926.	Do.
Do. .	(688) Seth Jagannath, Tumsar.	Do. . .	M. L. .	46	17th September 1926.	Do.
Do. .	(689) Seth Mohanlal Bridichand, Kamptee	Do. . .	M. L. .	75	19th August 1926.	15 years.
Do. .	(690) Mr. Shamji Narainji, Ramtek.	Do. . .	M. L. .	29	5th October 1926.	5 years.

MADRAS.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur .	(691) The North Anantapur Gold Mines Company.	Gold . . .	M. L. .	1,604·00	Not stated .	30 years.
Bellary .	(692) Sree Nageswara General Mining Company.	Manganese . .	P. L. .	71·90	28th April 1926.	1 year.
Do. .	(693) A. Pitchayya Nayudu.	Do. . .	P. L. .	35·85	17th August 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bellary	(694) A. K. Veerappa	Manganese	M. L.	4·38	22nd October 1926.	20 years.
Do.	(695) B. Ismail Sahib	Do.	P. L.	161·20	3rd November 1925.	1 year.
Do.	(696) Sree Nageswara General Mining Company.	Do.	P. L.	2,979·00	23rd November 1926.	2 years.
Cuddapah	(697) Nabi Sahib of Hindupur.	Barytes	P. L.	62·08	12th March 1926.	1 year.
Do.	(698) The Mysore Development Syndicate.	Asbestos	P. L.	30·51	16th February 1926.	Do.
Do.	(699) Do.	Do.	P. L.	538·93	20th February 1926.	Do.
Do.	(700) Do.	Do.	P. L.	463·46	Do.	Do.
Do.	(701) A. Ghose	Barytes	P. L.	127·58	24th June 1926.	Do.
Do.	(702) K. Venkatesayya	Do.	P. L.	39·65	1st December 1926.	Do.
Kurnool	(703) P. Venkayya	Diamonds	P. L.	224·73	8th March 1926.	Do.
Do.	(704) Do.	Do.	P. L.	211·31	26th February 1926.	Do.
Do.	(705) V. Venkatasubbiah.	Barytes	P. L.	1·35	18th January 1926.	Do.
Do.	(706) Rao Sahib D. Laxminarayan.	Manganese	P. L.	860·00	4th October 1926.	Do.
Do.	(707) Do.	Do.	P. L.	1,080·00	Do.	Do.
Nellore	(708) The Krishna Mining Company, Gudur.	Mica	M. L.	53·67	12th January 1926.	30 years.
Do.	(709) R. Sundara Rami Reddi.	Do.	M. L.	2·85	25th November 1925.	Do.
Do.	(710) T. C. Dandayudam Pillai.	Do.	M. L.	10·93	14th November 1925.	Do.
Do.	(711) P. Kesava Ramiah.	Do.	P. L.	14·15	23rd February 1926.	1 year.
Do.	(712) T. C. Dandayudam Pillai.	Do.	P. L.	33·07	23rd June 1926.	Do.
Do.	(713) R. Sundara Rami Reddi.	Do.	P. L.	10·08	Do.	Do.
Do.	(714) Do.	Do.	M. L.	148·71	9th February 1926.	30 years.
Do.	(715) R. V. Lakshmi Narasingha Rao.	Do.	P. L.	1·52	5th May 1926	1 year.
Do.	(716) P. Venkatasubba Reddi.	Do.	P. L.	73·14	7th May 1926	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(717) P. Venkatasubba Reddi.	Mica	M. L. .	38·02	18th June 1926.	30 years.
Do. .	(718) G. Chenchu Subba Reddi.	Do.	P. L. .	15·18	12th January 1926.	1 year.
Do. .	(719) G. Venkatachalam.	Do.	P. L. .	9·08	25th December 1925.	Do.
Do. .	(720) Do. .	Do.	P. L. .	1·80	14th November 1925.	Do.
Do. .	(721) T. C. Dandayudam Pillai.	Do.	P. L. .	13·33	28th October 1925.	Do.
Do. .	(722) Do. .	Do.	M. L. .	13·09	26th June 1926.	30 years.
Do. .	(723) P. Venkata Subba Reddi.	Do.	P. L. .	35·35	23rd February 1926.	1 year.
Do. .	(724) Nawab Ahmed Nawaz-Jung Bahadur.	Do.	P. L. .	25·49	16th December 1926.	Do.
Do. .	(725) P. Veera Reddi	Do.	M. L. .	187·46	21st November 1926.	30 years.
Do. .	(726) I. Ramasubba Reddi.	Do.	P. L. .	12·20	29th April 1926.	1 year.
Do. .	(727) G. Chenchu Subba Reddi.	Do.	M. L. .	2·86	16th August 1926.	30 years.
Do. .	(728) T. C. Dandayudam Pillai.	Do.	P. L. .	49·66	9th October 1926.	1 year.
Do. .	(729) P. Venkatasubba Reddi.	Do.	M. L. .	18·30	8th September 1926.	30 years.
Do. .	(730) Y. Subba Reddi	Do.	P. L. .	8·66	26th May 1926	1 year.
Do. .	(731) T. C. Dandayudam Pillai.	Do.	P. L. .	33·05	19th November 1925.	Do.
Do. .	(732) Do. .	Do.	M. L. .	55·27	13th November 1926.	30 years.
Do. .	(733) R. Venkata Krishniah.	Do.	M. L. .	54·75	7th September 1926.	Up to 11th June 1934.
Do. .	(734) A. Pitchayya Nayudu.	Do.	P. L. .	246·84	31st July 1926	1 year.
Do. .	(735) Do. .	Do.	P. L. .	15·46	9th February 1926.	Do.
Do. .	(736) R. Venkatanarasimhulu Chetti.	Do.	M. L. .	32·48	21st October 1926.	30 years.
Do. .	(737) Do. .	Do.	M. L. .	31·13	24th September 1926.	Do.
Do. .	(738) P. Venkatasubba Reddi.	Do.	P. L. .	26·47	23rd April 1926.	1 year.
Do. .	(739) B. Bangariah Chetti.	Do.	M. L. .	31·00	9th September 1926.	30 years.

P. L. = Prospecting License. *M. L. = Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(740) T. C. Dandayudam Pillai.	Mica	P. L. .	22·22	11th August 1926.	1 year.
Do. .	(741) B. Ramalingayya Chetti.	Do.	M. L. .	184·59	7th December 1926.	30 years.
Do. .	(742) B. Ramalingam Chetti.	Do.	M. L. .	128·96	31st July 1926.	Do.
Do. .	(743) P. Venkatasubba Reddi.	Do.	P. L. .	15·60	22nd November 1926.	1 year.
Do. .	(744) Syed Khaya Meich.	Do.	P. L. .	19·09	18th June 1926.	Do.
Do. .	(745) Muhammad Makdum Mohideen Sahib.	Do.	M. L. .	32·35	11th August 1926.	30 years.
Do. .	(746) T. Rama Reddi	Do.	P. L. .	10·37	18th September 1926.	1 year.
Do. .	(747) I. Ramasubba Reddi.	Do.	P. L. .	4·00	3rd September 1926.	Do.
Do. .	(748) S. V. Subba Reddi.	Do.	P. L. .	87·20	9th October 1926.	Do.
Do. .	(749) Muhammad Makdum Mohideen Sahib.	Do.	M. L. .	51·34	7th December 1926.	30 years.
The Nilgiris	(750) A. H. Gaston .	Do.	M. L. .	38·27	7th June 1926.	Do.
Do. .	(751) Do. .	Do.	P. L. .	32·17	9th October 1926.	1 year.
Salem .	(752) Srinivasa Raghavan.	Iron, Chromite and manganese.	M. L. .	1,220·34	12th April 1926.	30 years.

NORTH-WEST FRONTIER PROVINCE.

Dera Ismail Khan.	(753) The Indo-Burma Petroleum Company, Limited.	Mineral oil . .	P. L. .	2,995·2	10th September 1926.	1 year.

PUNJAB.

Attock and Shahpur.	(754) African Construction Corporation Limited.	Mineral oil . .	P. L. .	6,649·6 (5,209·6 in Attock and 1,440 in Shahpur).	22nd July 1926.	2 years.

P. L. = Prospecting Licence. *M. L. = Mining Lease.*

PUNJAB—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Attock and Shahpur.	(755) African Construction Corporation Limited.	Mineral oil . .	P. L. .	3,180·8 (1,625·6 in Shahpur and 1,555·2 in Attock).	29th July 1926.	2 years.
Jhelum .	(756) Subedar Hakan Khan.	Coal . . .	P. L. .	48·5	26th February 1926.	1 year.
Do. .	(757) Do. .	Do. . . .	P. L. .	13	15th February 1926.	Do.
Do. .	(758) Do. .	Do. . . .	P. L. .	57·5	13th December 1926.	Do.

P. L. = Prospecting License. *M. L. = Mining Lease.*

SUMMARY.

Province.	Exploring License.	Prospecting License.	Quarry Lease.	Mining Lease.	Total of each Province.
Ajmer-Merwara	..	27	..	6	33
Assam	..	30	..	1	31
Baluchistan	1	..	..	..	1
Bengal	..	6	..	..	6
Bihar and Orissa	..	2	..	1	3
Bombay	..	..	..	1	1
Burma	..	218	..	20	238
Central Provinces	..	287	4	86	377
Madras	..	40	..	22	62
North-West Frontier Province	..	1	..	..	1
Punjab	..	5	..	..	5
Total of each kind and grand total, 1926 .	1	616	4	137	758
TOTAL FOR 1925 .	1	737	..	121	859

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Ajmer-Merwara during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Ajmer	15	55·14	Mica.
Do.	1	2·00	Red oxide.
Beawar	1	4·00	Asbestos.
Do.	10	40·62	Mica.
TOTAL	27		
Mining Leases.			
Ajmer	5	4·65	Mica.
Beawar	1	0·97	Do.
TOTAL	6		

TABLE 43.—*Prospecting Licenses and Mining Lease granted in Assam during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Cachar	4	12,089·6	Mineral oil.
Garo Hills	6	6,702	Coal.
Khasi and Jaintia Hills	1	5,427	Minerals other than mineral oil.
Do. do.	1	5,427	Mineral oil.
Do. do.	1	2,880	Coal.

TABLE 43.—*Prospecting Licenses and Mining Lease granted in Assam during the year 1926*—contd.

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses—*contd.*			
Lakhimpur	7	30,165	Mineral oil.
Do.	2	13,120	Coal.
Nowgong	3	4,608	Crude petroleum and its associated hydro-carbons.
Sadiya Frontier Tract . .	1	2,240	Mineral oil.
Sibsagar	1	1,388·8	Crude petroleum and its associated hydro-carbons.
Do.	2	7,840	Coal and oil.
Sylhet	1	4,636	Mineral oil.
TOTAL .	30		
Mining Lease.			
Manipur	1	500	Copper.

TABLE 44.—*Exploring License granted in Baluchistan during the year 1926.*

DISTRICT.	1926		
	No.	Area in acres.	Mineral.
Exploring License.			
Sibi	1	42,240	Petroleum

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TABLE 45.—*Prospecting Licenses granted in Bengal during the year 1926.*

District.	1926. No.	1926. Area in acres.	1926. Mineral.
Prospecting Licenses.			
Chittagong	2	7,061·98	Natural petroleum.
Chittagong Hill Tracts . .	3	12,915·2	Crude petroleum and its associated hydro-carbons.
Do. do. .	1	4,313·6	Mineral oil.
TOTAL .	6		

TABLE 46.—*Prospecting Licenses and Mining Lease granted in Bihar and Orissa during the year 1926.*

District.	1926. No.	1926. Area in acres.	1926. Mineral.
Prospecting Licenses.			
Gaya	1	480	All minerals except oil and coal.
Singhbhum	1	952	Chromite.
TOTAL .	2		
Mining Lease.			
Singhbhum	1	224	Iron ore.

TABLE 47.—*Mining Lease granted in the Bombay Presidency during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Mining Lease.			
Kanara	1	116	Manganese.

TABLE 48.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Akyab	5	25,088	Natural petroleum.
Amherst	17	23,285·76	All minerals except oil.
Do.	2	12,800	Oil shale.
Do.	3	4,128	Antimony.
Do.	1	1,280	Sulphides.
Kyaukse	1	1,849·6	All minerals except oil.
Lower Chindwin . . .	5	14,955·2	Natural petroleum.
Magwe	4	3,456	Do.
Mandalay	1	1,996·8	All minerals except oil.
Meiktila	3	3,200	Do.
Mergui	18	14,316·8	Tin and allied minerals.
Do.	19	15,872	Tin.
Do.	14	10,908·5	All minerals except oil.
Do.	3	4,262·4	Tin and other minerals.
Do.	3	857·6	Tin and all minerals except coal and oil.
Do.	2	1,203·2	Tin and wolfram.
Do.	1	256	Cassiterite and tin
Do.	1	512	Tin and gold.
Minbu	3	1,548·8	Natural petroleum.
Myingyan	1	1,280	Do

TABLE 48.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1926*—contd.

DISTRICT.	1926. No.	1926. Area in acres.	1926. Mineral.
Prospecting Licenses—*contd.*			
Northern Shan States	2	377·6	Iron ore.
Do. do.	1	1,920	Lead and silver.
Pakakku	5	13,699	Natural petroleum.
Shwebo	2	10,553·6	Do.
Southern Shan States	16	37,299	All minerals except oil.
Do. do.	1	640	Gold.
Tavoy	57	34,300·16	Tin and wolfram.
Do.	1	217·6	Cassiterite and wolfram.
Do.	1	211·2	Cassiterite.
Do.	1	25,120	All minerals except natural petroleum.
Do.	1	4,288	Cassiterite, wolframite and molybdenite.
Thaton	4	8,497·92	All minerals except natural petroleum.
Thayetmyo	11	17,852	Natural petroleum.
Toungoo	1	320	All minerals except oil.
Upper Chindwin	2	1,344	Coal.
Do.	4	8,160	Natural petroleum.
Yamethin	1	620·8	All minerals except natural petroleum.
TOTAL	218		
Mining Leases.			
Mandalay	1	11·96	Iron ore.
Mergui	1	1,971·2	Tin and all minerals except oil and coal.
Myingyan	1	2,675·2	Natural petroleum.
Pakakku	2	3,340·8	Do.
Southern Shan States	1	40	Lead and silver.
Do do.	1	4,172·8	All minerals except natural petroleum.
Tavoy	6	1,379·9	Tin and wolfram.
Do.	1	117·7	Tin and allied minerals.
Do.	4	2,348·1	Tin.
Do.	1	256	Tin, wolfram and allied minerals.
Do.	1	819·8	Tin, wolfram and bismuth.
TOTAL	20		

TABLE 49.—*Prospecting Licenses and Mining and Quarry Leases granted in the Central Provinces during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Balaghat	117	12,502	Manganese.
Bhandara	36	4,041	Do.
Bilaspur	2	202	Do.
Do.	2	31	Mica.
Do.	4	20,092	Coal.
Do.	1	11,900	Coal and iron.
Do.	1	119	Limestone.
Chhindwara	4	1,001	Coal.
Do.	20	3,413	Manganese.
Do.	1	168	Graphite.
Do.	1	45	Manganese and pyrites.
Jubbulpore	4	682	Bauxite.
Do.	15	2,325	Manganese.
Nagpur	79	8,625	Do.
TOTAL	287		
Mining Leases.			
Balaghat	3	51	Mica.
Do.	27	1,392	Manganese.
Bhandara	10	401	Do.
Chanda	1	1,016	Do.
Chhindwara	4	830	Coal.
Do.	4	393	Manganese.
Do.	1	3	Limestone.
Jubbulpore	3	37	Manganese.
Nagpur	33	2,123	Do.
TOTAL	86		
Quarry Leases.			
Nagpur	3	66	Limestone.
Do.	1	29	Clay.
TOTAL	4		

TABLE 50.—*Prospecting Licenses and Mining Leases granted in Madras during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Bellary	4	3,247·95	Manganese.
Cuddapah	3	229·31	Barytes.
Do	3	1,032·90	Asbestos.
Kurnool	2	436·04	Diamonds.
Do.	1	1·35	Barytes.
Do.	2	1,940·00	Manganese.
Nellore	24	782·60	Mica.
The Nilgiris	1	32·17	Do.
TOTAL	40		
Mining Leases.			
Anantapur	1	1,604·00	Gold.
Bellary	1	4·38	Manganese.
Nellore	18	1,082·76	Mica.
Salem	1	1,220·34	Iron, chromite and manganese.
The Nilgiris	1	38·27	Mica.
TOTAL	22	..	

TABLE 51.—*Prospecting License granted in North-West Frontier Province during the year 1926.*

DISTRICT.	1926.		
	No.	Area in acres.	Mineral.
Prospecting License.			
Dera Ismail Khan	1	2,995·2	Mineral oil.

TABLE 52.—*Prospecting Licenses granted in the Punjab during the year 1926.*

District.	1926.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Attock and Shahpur . .	2	9,830·4	Mineral oil.
Jhelum	3	119·0	Coal.
TOTAL .	5		

NOTES ON A GEOLOGICAL TRAVERSE IN THE YUNZALIN VALLEY. BY E. L. G. CLEGG, B.SC., *Assistant Superintendent, Geological Survey of India.* (With Plate 23.)

Introduction.

The following short paper is prepared from observations recorded on a journey in April and May, 1922, the object of which was to investigate the geological feasibility of the Yunzalin Hydro-Electric Scheme, a scheme proposed by the Hydro-Electric Survey of Burma for the construction of a dam on the Yunzalin River south-west of Theithamudo (18° 24′ ; 97° 14′) and the impounding of water in the upper reaches of that river and its tributaries, the chief of which is the Thelaw Klo.

The route taken to the area was from Shwegyin in the Pegu District *viâ* Minlan-tazeik and Lewa to Pyagawpu on the Thelaw Klo, whilst the return route followed the upper course of the Bilin River for about 25 miles and then cut south-east by east *viâ* Tekaido and Mawkawdo to Papun on the Yunzalin River. From Pyagawpu a circular tour of the impoundment area was made *viâ* Tisita Sakan, Lomati, Keyudo, Lomati, Toebawdo, Theithamudo and Pawlawdo (see Plate 23.)

Owing to the imminence of the rains, the visit was necessarily very hurried, and in the journeys to and from Pyagawpu, the geological details noted were nearly all seen on the tracks taken, traverses being rarely made into the surrounding country. The greater part of the area examined lies in the West Salween district and is very sparsely inhabited by Hill Karens, a sturdy, self-contained race, who have sufficient for their needs and in that meagre sufficiency are content.

Previous observers.

The only previously published geological reference to the area occurs in Theobald's "Stray Notes on the Metalliferous Resources of British Burma" where a reduced sketch map (12 miles=1 inch) of the journey of Major O'Riley, a district officer of Martaban, is reproduced.[1] In the map only mineral occurrences are shown.

[1] *Rec., Geol. Surv. Ind.*, Vol. VI, Pt. 4.

Maps.

The following excellent 1 inch =1 mile maps (new series) of the Survey of India cover the area traversed: $94\frac{C}{13}$, $94\frac{B}{16}$, $94\frac{F}{4}$, $94\frac{F}{3}$, $94\frac{F}{2}$, and $94\frac{F}{8}$.

Physical Features.

Shwegyin (17° 55′; 96° 47′) is situated on the Sittang River in the Pegu district at a relative height above sea level of 55 feet and Papun (18° 4′; 97° 26′) on the Yunzalin, a tributary of the Salween, at a relative height of 300 feet above sea level. Between these two towns lies the catchment area of the Yunzalin. They are separated by the mountainous chain of the Yoma Kyo which divides the drainage of the Salween from that of the Sittang, and forms the western boundary of the Yunzalin basin. Peaks on this mountain chain rise to a height of over 5,000 feet and form a formidable barrier to cross. On the east, the Yunzalin basin is bounded by a slightly lesser range which merges into the former in the north, at the high peak of Mt. Nattaung (8,607 ft.). In a south-east by south direction this latter range passes east of Papun, and separates the Yunzalin basin from the main Salween drainage; on the south, a subsidiary chain separates the Bilin drainage from that of the Yunzalin.

The part of the Yunzalin catchment which was examined in the greatest detail lies in the angle of the two great mountain chains mentioned, Mt. Nattaung forming the northerly apex. It varies in height from 2,460 to 5,000 feet and is split up into narrow V-shaped valleys whose sides are covered by dense forests. On the higher slopes in the northern part of the area pines predominate but are absent in the south along the Thelaw Klo. The crests of the spurs and ridges are narrow and knife-edged, and it is along these that many of the tracks, which form the only means of transit in the district are found. On the slates and quartzites of the Chaung Magyi series the ridges run parallel to the strike of the rocks, which varies from due north in the north, to north-west by north in the south; the granite masses are characterised by radiating spurs, and the outliers of crystalline limestone west of Tisita Sakan by bare, precipitous, and tufa-covered slopes. The whole area is a southern continuation of the Shan Plateau but differs from it in being more rugged, more thickly afforested and more inaccessible. Journeying from west to east the sharp change in scenery from the deltaic type is most marked; at Minlan-tazeik the Sittang, a meandering river with numerous cut-offs, which has reached its

base level of erosion flows sluggishly southwards, whilst north-east of Lewa, a bare sixteen miles away the Shwegyin River dashes over granite blocks amid a mist of spray. East of the Yoma Kyo the drainage is in a south by east direction, in correspondence with the main tectonic lines; westwards it flows to the Sittang. All the streams are perennial.

Stratigraphical divisions. The rocks exposed in the area have been placed in the following divisions:—

1. Plateau Limestone,
2. Granite,
3. Chaung Magyi series,
4. Gneisses with intruded granites, quartz veins and (east of Papun) bands of crystalline limestone.

Gneisses. The gneisses are rocks of the Archæan complex and rank among the oldest known rocks of the world. Although many different types are found among them, their structure and metamorphism is so complex that their various relations have not yet been determined. In various parts of the world the Archæan system is known to include sediments all more or less metamorphosed and has been so sub-divided; in Burma no such division has been made, although it has been tentatively suggested that the overlying Chaung Magyis, about whose age it can only be said that they are pre-Cambrian and post-gneissic, although they are naturally classed as Cambrian, may be the equivalent of the uppermost members of the Dharwars of India. In the west of the area traversed, gneisses of probable igneous origin and metamorphosed sediments are inextricably folded and faulted into each other. Although the gneissic series was best seen on the Yunzalin River west of Lomati and east of Papun, there is little doubt that they also underlie the laterite east of the Sittang valley and form the eastern flank of the plateau. Gneiss underlies laterite in Shwegyin town on the road between the dak bungalow and the town bazaar, whilst quartzites exposed on the hills south-east of Wadawatet probably represent quartz bands in the same series. From the Mallan River-Shwegyin River junction eastwards to within half a mile of the junction of Kano Law with the Shwegyin, are a series of gneissose granites, quartzites, grey gneisses and felspathic grits, and at one place specimens of a quartz garnet epidote rock were collected. Their mutual relationships are indeterminable, but

from the predominance of gneissic types they were classed as gneisses, though probably a certain amount of Chaung Magyi slates and quartzites are included in them. West of Lomati, predominant gnessic types are of the porphyritic streaky and fine-grained biotite varieties, although a streaky hornblende biotite gneiss also occurs; further west beyond Keyudo village, quartz bands 20-30 feet thick are found intercalated in the series, which have a general northerly strike. Acid felspars, albite, oligoclase and orthoclase characterise the gneisses, the latter felspar, commonly showing carlsbad twinning, forming the larger phenocrysts in the porphyritic varieties.

On the stream which joins the Yunzalin River on the east bank about 3½ miles north of Papun, and flanking the river, biotite gneisses with included bands of crystalline limestone are found. They probably form the mountain range to the east and continue south along the Siamese frontier to Myawaddy, whence, Coggin Brown notes, sapphires and rubies have been reported.[1] Granite gneisses and mica schists are also found round the peripheries of the granite masses, but these are very local and due to differential movement and thermal metamorphism at the time of intrusion.

Chaung Magyi Series.

The type locality of the Chaung Magyi rocks is in the Northern Shan States where they have been described by LaTouche.[2] There they are unfossiliferous but are found overlying gneisses of the Mogok Archaic suite and underlying rocks of the Naungkangyi series, from which series an Ordovician fauna has been collected. LaTouche describes them as "a series of quartzites generally of a red or brown colour, occasionally containing a little felspar when they may be called greywackes: slaty shales generally dark blue in colour and sandstones." In the Yunzalin area they are very similar and consist of slates, usually quartzose, micaceous quartzitic schists, quartzitic schists and quartzites. All grades from a dark blue, cleaved, though broken, slate, to a hard light coloured quartzite are present. Under the microscope the slates are seen to contain secondary quartz and biotite mica; the quartzites a little oligoclase felspar, biotite, muscovite and zircon. In banded micaceous varieties the quantities of quartz and mica in the bands are inversely proportional.

[1] *Rec., Geol. Surv. Ind.*, Vol. LVI, page 96 footnote.
[2] *Mem., Geol. Surv. Ind.*, Vol. XXXIX, Pt. 2.

Rocks referred to this series were first noted on the outward journey on the Shwegyin River and continued to east of Lewa. First seen as rather weathered and broken shales, they pass, west of the village of Nattaung into slates and slaty schists dipping north-east at angles varying from vertical to 70°, and these into hard slates and quartzites at the ford at Lewa village. They are next seen forming the valley of the Kano Law, and from thence are continuous into the Yunzalin catchment area. The valley of the Kano Law is composed of fairly coarse blue slates well exposed north-west of Mawlaw village, but from hence exposures are very rare on the hill track to Pyagawpu (18° 20′; 97° 6′) on the Thelaw Klo. The impounding area of the Yunzalin catchment basin consists almost entirely of the same series of rocks and the Yunzalin and its chief tributary the Thelaw Klo are difficult streams to work along owing to the extremely varying nature of the slates and quartzites; where the softer slates occur pools have been scoured out by the stream; where quartzites, rapids are formed, and at places where the quartzites attain a great thickness, veritable defiles. At Thei-thamudo where it was proposed to build the main dam, the Yunzalin flows in such a defile through a thick series of hard dark blue slates and quartzites, very difficult to traverse owing to their smooth polished surfaces. The quartzites dip across the stream in a W. 25° S. direction and are underlain by banded varieties of quartz schist. This banding is at right angles to the dip of the quartzites, that is, at right angles to what appears to be the bedding of the series.

The cleavage and banding dips of the slates and quartzites are generally vertical, the dip rarely varying from between the limits 60° E. 20° N. and 60° W. 20° S. Small faults and slips are common, but from the stringing out of bands along the fault and slip planes, must have occurred when the rocks were in a plastic condition.

Between Pyagawpu on the Thelaw Klo and Pawsuko, about twenty-five miles to the south-east on the Bilin River, Chaung Magyi rocks form a narrow inlier along which the Bilin flows. A big valley of Chaung Magyi rocks occurs but is obscured by overlying limestone and this is seen south-east of Pyagawpu, at Tapawdo at the head of the Bilin, where the valley is relatively open and unforested. Limestone flanks the slates of the stream bed but higher up the slopes of the V-shaped valley, the hill sides are again found to be composed of Chaung Magyi slates.

One and a half miles south of Tapawdo, cleaved limestone, together with a small syncline composed of alternating bands of slate and crystalline limestone, each band on an average about 1 inch thick and weathering in a manner very reminiscent of the calcareous gneisses of the Central Provinces, is seen. South-east of Tahedo biotite gneisses and granite are included in the slate quartzite series, but exposures are very poor indeed as the stream bed is filled with large boulders and the banks covered by thick forest.

At Tidemuta Sakan the valley broadens out, and a small boss of granite is intruded into the Chaung Magyis and forms a hillock in the centre of the valley. It probably forms an offshoot from the large biotite granite boss to the east, over which the upper course of the Mawlaw Klo flows to the Tekaido-Lawpodo valley. Between Tekaido and Papun, the path passes over typical strike valleys of slates and quartzitic slates of the Chaung Magyi series. Similar rocks probably form the valley of the Yunzalin north by west of Papun, and connect up with the slate-quartzite series forming the bed of the river at Theithamudo.

Plateau Limestone.

In the Northern Shan States LaTouche[1] has described both Devonian and Permo-Carboniferous limestones forming the plateau proper. These are collectively known as the Plateau Limestone, despite the long range in geological time which they cover. The Devonian limestones consist of much crushed crystalline dolomites and limestones containing a numerous assemblage of Devonian fossils which include *Calceola sandalina*, *Phacops*, *Pentamerus*, etc.; the Permo-Carboniferous are partly dolomitised and brecciated limestones generally unfossiliferous, but from which *Fusulina* and *Productus* have been obtained. In the Tenasserim division near Pa-an, River, on the Salween about 40 miles north of Moulmein, in the massive limestones known as the Duke of York's Nose, specimens poorly preserved but undoubtedly referable to the genus *Productus*, were collected by the late Captain F. W. Walker. This latter series is intermittently continuous with the limestones of the Yunzalin by way of the Bilin River, and for this reason the limestones of the Yunzalin are referred to the Permo-Carboniferous, but until the intervening areas have been linked up by continuous mapping, a doubt must still exist.

[1] *Op. cit.*

In the Yunzalin area the series consists of unfossiliferous, brecciated crystalline limestones; they are blue in colour, lie unconformably on slates and quartzites of the Chaung Magyi series, are fissured and characterised by swallow holes and dry valleys. In their typical development they form two high plateau-like outliers from south-west to north-west of Tisita Sakan. Their eastern boundaries are precipitous and tufa-covered, whilst the vegetation on them is, in comparison with that on the Chaung Magyi series, sparse. The base of the cliffs is demarcated by a line of swallow holes, and a stream emerges from a cave at the southern end of the more northerly outlier. From its volume, this stream appears to drain a considerable area, and there is no doubt that these limestone outliers lie in a valley of the Chaung Magyis. Another mappable outlier of limestone occurs at Toebawdo on the Yunzalin. Its eastern margin is underlain by quartzites of the Chaung Magyis and its western is faulted down to slates of the same series. Small isolated exposures of limestone were also noted lying in strike valleys at the following places:—

(1) One-and-a-quarter miles west-by-north of Sukhido N.
(2) One mile south of Sukhido S.
(3) Lomati.
(4) Pyagawpu.

The above comprise the whole of the limestone outliers seen in the catchment of the Yunzalin above the proposed dam site at Theithamudo, but on the return journey to Papun massive limestones were found flanking the valley of the Bilin River.

Immediately on descending into the head-waters of the Bilin River, after crossing the low watershed which separates this stream from the Thelaw Klo, isolated pinnacles and hummocks of crystalline limestone are found lying on the Chaung Magyi series. That these are only local, is evident from the occurrence at Tapawdo of slates and quartzites higher up the sides of the valley. The upper Bilin valley appears to form a defile, the flanks being formed of precipitous limestone cliffs, and the base of Chaung Magyi rocks, the latter covered by dense leech-infested forest. It is only when the stream approaches the flank that the limestone cliffs are apparent, but from the comparatively rare exposures seen, these appear to get higher and more precipitous downstream to the south-east; at Tapawdo at the head of the Bilin valley small isolated pinnacles and hummocks were noted; at Tedodita Sakan opposite the village

rest-house, a cliff of crystalline limestone rises vertically from the eastern bank of the stream, whilst four miles below, massive fissured crags of limestone overlook the rocky stream course. Towards Tidemuta Sakan, where fairly big tributary streams join the Bilin, the valley broadens out for a few miles and patches of land are cultivated by the local Karen villagers. From the centre of this area, a magnificent view is obtained to the north, east and south, of high fissured crags, pinnacles, and limestone cliffs giving beetling and castellated effects. The path to Papun leaves the Bilin at this point and, ascending the hills to the east, passes through a narrow col at Pt. 2260 near Lawwakodo village. The sides of the col are formed of limestone cliffs and the track passes round a swallow-hole, practically on the watershed, before descending on to biotite granite forming the bed of the Mawlaw Klo.

Lead ores were reported by Major O'Riley[1] on the limestone outliers west of Tisita Sakan.

Intrusions.

Plutonic and hypabyssal rocks were found intruded into rocks of the Gneiss and Chaung Magyi series; nowhere were they found intruded into the Plateau Limestone formation. Limestone was however found overlying granites in the Chaung Magyis both west of Tisita Sakan and again in the Bilin River bed, but owing to the general crystallinity of all the limestones seen, it was impossible to say if any of the metamorphism had been occasioned by the granite. This is unfortunate as in view of the resistance which limestones occasionally show to acid igneous intrusion, it is within the bounds of possibility for granites to be intruded in post-Plateau Limestone times and yet for the intrusion to cease at the Chaung Magyi-Limestone junction. That igneous activity in this area has occurred subsequent to the limestone period is clearly shown by lead ore veins in the limestones, as reported by Major O'Riley, the latter probably contemporaneous with the lead ores found in the limestones of the Heho area in the Southern Shan States. However, all the evidence gathered strongly favours the view that the plutonic and hypabyssal rocks of the area were intruded in pre-limestone times.

Granites.

Granites are found intruded as large bosses in either gneisses or rocks of the Chaung Magyi series.

[1] *Op. cit.*

North of Shwegyin on the Minlan-tazeik road, biotite granite protrudes in isolated hummocks through the laterite between Chedawya and Thayetchaung. It is rather weathered, and is probably intruded into the older gneisses although it must be stated, that the only outcrops of crystalline rock, other than granite, that were seen, were isolated outcrops of quartzite south-east of Wadaw-atet, and gneisses underlying laterite in Shwegyin town.

North of Lewa is a large boss of coarse biotite granite in which boulders of finer aplitic granite are occasionally met. The track from Lewa to Pyagawpu passes over the boss for a distance of about six miles; the track is very rough and winds northwards through thick forest parellel to Shwegyin River over huge blocks of granite; it crosses innumerable spurs and small streams, the latter tributaries of the Shwegyin, which flow from the heights to the west down deeply dissected valleys to the torrential course of the main stream below. The granite is very homogeneous in both composition and texture in the main boss, but on its eastern flank near the Mallan-Shwegyin junction it becomes gneissose.

The best exposed boss occurs on the Thelaw Klo definitely intruded into the Chaung Magyi series. The river flows across its southern boundary and small isolated areas of Chaung Magyi rocks were mapped lying on its upper surface. The same boss cuts the Yunzalin about one mile west of the Yunzalin-Thelaw-Klo junction and as it typifies the granites seen, its more important characteristics are given. It consists of large phenocrysts of orthoclase felspar in a matrix of quartz, oligoclase felspar and mica. The orthoclase felspar is predominant and occurs as large phenocrysts twinned on the Carlsbad law, whilst the subordinate oligoclase felspar occurs in the groundmass twinned on the albite law; both muscovite and biotite mica are found in the groundmass together with a considerable amount of quartz; the felspars and quartz commonly show strain phenomena and the granite is slightly gneissose. It is of a definite potash type.

On the Thelaw Klo, slates and quartzites are caught up in this granite, whilst veins of granite and pegmatite radiate into the surrounding Chaung Magyi series. The latter had in isolated cases suffered thermal metamorphism and been altered to mica schist, but as the blocks caught up showed little alteration, some predisposing factor must have existed in the rocks so altered. On the west,

the granite passes gradually into the Chaung Magyis through an area of granite gneiss.

Another small boss occurs in the valley of the Bilin at Tidemuta Sakan and is probably connected with the larger boss to the east down which the rocky course of the Mawlaw Klo descends to Tekaido.

Pegmatites.

Pegmatites were seen associated with the granite mass on the Thelaw Klo. They are not common but are very normal in type consisting of coarsely crystalline quartz, felspar, muscovite mica and tourmaline.

Felspar porphyry.

On the Thelaw Klo south-east of Tokido, a sericitised and glomeroporphyritic felspar porphyry was noted. Although its microscopical characters were masked by its weathered and altered condition, its field characters were clear. It definitely cut both a granite dyke and Chaung Magyi slates and represents one of the later phases of igneous activity in the area.

Epidiorite.

Due south of Sawpedo Auk, a dyke of epidiorite strikes across the Shwegyin River in a S. 30°E. direction, and is intrusive into a rather brecciated quartzite. The rock is a tough, fresh-looking, hornblendic one, and it is only on microscopical examination that its true characters are revealed. No evidence of its age other than that it is post-Chaung Magyi is obtainable.

Under the microscope it is found to be a holocrystalline, hypidiomorphic, porphyritic rock, composed of large phenocrysts of hornblende, and smaller ones of felspar, in a fine-grained groundmass of smaller hornblende crystals and small lath-shaped felspars. The hornblende phenocrysts are pale green in colour, pleochroic in yellow and bottle green, idiomorphic, and commonly show simple twinning, whilst basal sections show the characteristic amphibole double cleavage. The centres of the larger hornblende crystals consist of a colourless augite; in the groundmass the hornblende is granular. The felspar phenocrysts are of the plagioclase variety and show fairly broad lamellar twinning and labradorite extinction angles; in the groundmass, the felspars are distinctly more acid (oligoclase-andesine). Chlorite is seen as an alteration product probably after biotite, and iron ore is scattered throughout the rock. Originally a porphyritic dolerite, metamorphism has caused the alteration of the augite to hornblende, and the rock is now an epidiorite.

Laterite occurs all along the route followed from Shwegyin *viâ* Minlan-tazeik to the Shwegyin River. It is quarried in Shwegyin town, where it attains a thickness of 30 feet, by jail prisoners for use as a building stone and road metal. One-and-three-quarter miles west-by-south of Sawpedo-Auk, residual nodules of highly magnetic iron ore are found sparsely scattered over the lateritic surface.

Laterite.

Folding has taken place on a general N. 20° W. strike and the topographical features follow this trend. The whole area has a pronounced easterly tilt being in this respect similar to the Shan States to the north. Beyond mention of this strike and tilt, little further can be said of the structure of the rocks of the area as the original bedding of even the limestones, the most recently formed, has been lost. There seems little doubt however that the head-waters of the Yunzalin lie in either an eroded valley of older gneisses or more probably, a broad syncline, as the main Yoma Kyo and its subsidiary range appear to be formed of older gneiss, whilst the included angle is filled in by rocks of the Chaung Magyi series, overlain in the very centre of the catchment area by the high limestone outliers west of Tisita Sakan, whose southerly continuation is demonstrated by the massive limestones of the Bilin River. A point, which it may be as well to emphasise in connection with the Plateau Limestone series in the area examined, is that they almost always occur in valleys of Chaung Magyi rocks and their drainage is dependent not on the topography of the limestone, but on that of the underlying slates and quartzites. For how far down the Bilin River the Plateau Limestone is found forming the higher flanks of the valley it is impossible to say, but east-by-south of Tidemuta Sakan limestone covers the Chaung Magyi watershed both north and south of Pt. 2260.

Structure.

During my visit my work was greatly facilitated by the kind help of Mr. Seymour and Mr. Stock, both of the late Hydro-Electric Survey of Burma to whom I accord my most hearty thanks. Without their aid the journey would have been well nigh impossible as the jungle is in places very thick and the villages lie hidden away off the narrow tracks, whilst the inhabitants, Hill Karens, speak only their own local dialect.

Conclusion.

THE AMBALA BORING OF 1926-27. BY E. L. G. CLEGG, B.Sc., *Assistant Superintendent, Geological Survey of India.* (With Plate 24.)

Introduction.

IN 1916, the North Western Railway Co. referred to the Director, Geological Survey of India, the question of the water supply of Ambala. Two years later they again referred to the same question, as it was proposed to put up a joint engine shed for the East Indian Railway and North Western Railway, and calculations had shown that it was essential that a supply of at least $3\frac{1}{2}$ lakhs of gallons of water per day, should be available. The Chief Engineer in his letter mentioned the following alternatives for obtaining this supply :—

(1) tapping water at a considerable distance from the station in one of the numerous *chos* flowing from the Siwalik Hills, in which case the initial cost would be extremely heavy,

(2) trying a deep boring ;

and enquired if the Director, were of the opinion that a boring of a maximum depth of 2,000 feet was likely to meet with a fair measure of success. Dr. E. H. Pascoe, replying for the Director, reviewed the available information and discussed the proposed undertaking in the following words : "The opinion was expressed so long ago as 1872, that there were grounds for hope which would warrant further boring at Ambala after the failure of the 700[1]-foot bore. This opinion I endorse. I need not point out that it is based on probabilities, our knowledge of the deposits and structure being derived almost entirely from the boring. Risks must be faced in all new artesian experiments ; in this case I think the evidence justifies the experiment. Medlicott and Oldham were evidently under the impression that the Gangetic alluvium might be pierced at Ambala, and the subjacent Tertiaries tapped. This in the light of more recent work, is improbable, but their prognostication that water would be obtained in the Ambala boring was justifiable as water was

Geological justification for the boring.

[1] *Rec., Geol. Surv. Ind.*, Vol. XIV, p. 234.

found in every sand pierced. In accounts of this old well I can find no account of perforation of the pipe, so that the successive water yields obtained represented the water of one or two thin horizons only. Water from upper sands was more or less shut off by the pipe before lower sands were entered. If all the sands had been tapped conjointly by perforating the pipe, they might have produced a more serviceable yield. The thick clay deposit in which the 700 foot boring ended, is, on the whole, a favourable factor, since it is evidently an efficient cap for any water that may exist below. The probabilities are against its being over 1,000 feet thick. Perhaps the riskiest factor is the freshness of the water. There is no strict rule correlating the depth on the one hand, and the presence of salt on the other. In the N. Punjab the salt is largely derived from Nummulitic beds, and beds of this age crop out to the N. E. of Ambala; they are not described as saliferous here, however. The water encountered in the Ambala 700-foot bore was I believe fresh. I think a boring to a depth of 2,000 feet is reasonably likely to be successful in obtaining a substantial supply of water, and the chances are more in favour of its being fresh than of its being salt."

Boring commenced.

On the 30th June 1925 as a result of this advice, the Chief Engineer, Northern Command informed the Director, Geological Survey of India, that the Electrical and Mechanical Branch, Royal Engineers, were sinking an experimental deep tube-well at Ambala with a view to obtaining an artesian supply of water, and that the bore had then been sunk 700 feet.

Since that date the Geological Survey of India have been in close touch with the project, and monthly progress reports of the driller and samples of the various strata passed through have been forwarded to the Geological Survey of India office, the former for record and the latter for verification.

In November, 1925, Mr. E. J. Bradshaw, Assistant Superintendent, Geological Survey of India visited the bore and reported on—

(1) the methods employed in boring;

(2) the methods of taking samples.

Methods employed.

(1) The boring apparatus consisted of the usual steam plant for supplying the power required for a Star Percussion Drill of the largest size (No. 30), capable of drilling to a maximum depth of 3,000 feet. The boring started with a pipe of 14-inch diameter and at the time of Mr. Bradshaw's

visit a depth of over 1,200 feet had been drilled, the diameter of the pipe being then 8 inches so that it was expected that a depth of 2,000 feet would be easily attained. The driller in charge, Mr. Haslett, stated that the boring was the most difficult he had ever encountered, as the strata through which the bore had passed were all alluvial and not self supporting, and that there had been frequent inrushes of sand, which choked the pipe and necessitated a suspension of boring until the pipe could be cleared.

The practical result of this, was that drilling was usually limited to within the pipe itself, and the rate of drilling very spasmodic, depending upon the amount of time wasted in clearing the pipe. Further, the beds of clay passed through were particularly difficult to bore as the clay did not sludge, with the result that the drilling tools frequently bound.

Methods of taking samples.

(2) The samples taken were all grab samples, that is, samples of sludge obtained at intervals of five feet. Mr. Bradshaw was in agreement with the driller that that was the best method possible of obtaining the same, especially as great care was taken in securing the samples, and that the inaccuracies that did creep in, owing to inrush of sand, were unavoidable and seldom interfered with the sampling.

Strata pierced.

Mr. Bradshaw recommended that the description of each sample should be checked by a Geological Survey officer in Calcutta. This has been done from samples sent down and the chart (Plate 24) summarises the results obtained. Speaking very generally, the strata consist of alternations of sands and clays of from forty to fifty feet in thickness and mixed in varying proportions, whilst occasionally bands of gravels are encountered. The sands and clays are calcareous, the clays being generally much more so than the sands and gravels; in many cases clay samples contained gravel-like masses cemented by calcium carbonate. The chart is found to be in general agreement for the first seven hundred feet with the record of the 1872 Ambala boring.

The greatest thickness of sand passed through was 85 feet (from 1010-1095 ft.) and of clayey material 135 feet (from 415-520 ft.) whilst from 855-940 feet a thick calcareous clay series was encountered. At a depth of about 400 feet gravels consisting mainly of quartz pebbles were passed through.

The sands vary from fine micaceous to coarse micaceous and are pepper-and-salt in colour, the clays from buff to red-ochre coloured.

During the month of June 1926, 68 feet of sediment were drilled, and by July the 9th a further 11 feet had been completed, the depth of the bore having then reached 1,612 feet, the maximum depth attained.

Difficulties met in boring.

Difficulties were met with in increasing intensity owing to the inrush of sand and mud into the pipe, which filled up continuously, so that by the end of the month, the bore was to all intents and purposes out of hand, and the driller in his report stated that—

(1) for the last three weeks no progress had been made,
(2) it was impossible to drive the tubing without damaging it,
(3) it was impossible to clear out the bore to the bottom owing to the irremediable inrush of sand and mud,
(4) whilst he was still endeavouring to drill deeper, he had not much hope of success,
(5) in his opinion, it was impossible to sink the bore to a greater depth than that attained.

August, 1926, was spent in an endeavour to clean out the bore but with no success, and no further progress was reported during the year.

Situation on January 14th, 1927.

The situation as reported on January 14th, 1927, by the Garrison Engineer, Ambala, to the Geological Survey of India, was that the 4-inch tube had been shot off at 1,200 feet but could not be withdrawn, and that the bore having filled with liquid clay to 580 feet, had, by bailing, been reduced to about 608 feet, but that it was impossible to get below this depth by that method. The only alternative that now remained, was to test the water at the 600-foot level and to do this the 4 inch, 6-inch and 8-inch casing must be removed, and the 10-inch casing perforated either by " shooting off " or cutting. Owing to the risk attending the shooting off process, cutting was decided on and the well shut down to await the arrival of cutters from England.

It is unfortunate that the risks attending the shooting off process were not sufficiently considered when first it was decided to perforate the pipe at the various water bearing horizons, as owing to the

failure of the shooting-off of the 4-inch pipe at the 1,200-foot level, it is now only possible to test the yield from the surface down to the 600-foot level, which is but a small proportion of the 1,612 feet actually drilled. No definite evidence bearing on the remarks regarding the combined yields from the various sands made by Dr. E. H. Pascoe, on the water supply of Ambala, from the point of view of boring have been obtained.

Geological results of boring.

From the practical point of view the boring has provided a record of 1,612 feet of Indo-Gangetic alluvial strata, and has shown that whilst the Indo-Gangetic alluvium in general may be looked upon as a natural reservoir of sweet water, the strata vary so rapidly in the Ambala area that the chances of obtaining a copious supply of water under artesian conditions, from any one band of sand are poor. These results may have an extended application in dealing with subterranean water supplies all along the foot-hills of the Himalaya.

ON SOME FOSSIL INDIAN UNIONIDÆ. BY B. PRASHAD, D.SC., F.R.S.E., *Superintendent, Zoological Survey of India, Indian Museum, Calcutta.* (With Plate 25.)

(Published by permission of the Director, Zoological Survey of India.)

THIS short paper deals with three lots of fossil Unionidæ which have been sent to me from time to time by the Geological Survey of India for examination and report. Two of the lots are from the Upper Siwalik Beds near Jammu, while the third consists of a large conglomerate of Unionid shells found near Nawapet, Hyderabad, Deccan.

In this paper I have only given descriptions and figures of the various species, as I hope later to deal with the question of the distribution of the fossil Unionids of India and their relationships to the recent species.

Genus: LAMELLIDENS Simpson.

1925. *Lamellidens*, Prashad, *Rec. Geol. Surv. Ind.*, LVI, p. 300.

References to this genus will be found in the paper cited above. In the same paper I published figures of the casts of shells of a species of the genus *Lamellidens* from the Karewas of Kashmir. Owing to the scanty material available I refrained from giving either a description or a name to the Kashmir species, and was even doubtful as to whether the species was generically correctly placed, but the discovery of a species from the Upper Siwaliks near Jammu leaves no doubt that my conclusions were correct.

There are two fairly well preserved shells of a species from near Jammu before me, and, though owing to the two valves in each specimen being firmly united, it is not possible to study the hinge, there can be no doubt that they are members of the genus *Lamellidens*. They represent an undescribed species for which I propose the name *L. jammuensis*.

It would not be without interest to note here that the first fossil species of the genus *Lamellidens* was described by me under the name *L. vredenburgi*[1] from the Intertrappean Beds of the Narbada,

[1] Prashad, B. *Rec. Geol. Surv. Ind.*, LI, pp. 368, 369, pl. xii, figs. 1, 2, (1921).

and another species, *L.* (?) *quadratus*, from the oil-beds of the Dawna Hills, Tenasserim, was doubtfully assigned to the genus by Annandale.[1]

LAMELLIDENS JAMMUENSIS, sp. nov.

(Pl. 25 fig. 1).

Shell elongate, subrhomboidal; fairly thick, moderately convex; inequilateral with a well marked posterior wing; regularly but narrowly arched below; umbones not prominent, slightly inflated, without any definite sculpture; surface weathered, but with a number of distinct concentric lines of growth; posterior ridge slightly arched, low, passing into the short posterior margin; anterior margin broad, regularly curved and passing gradually into the slightly arched ventral margin; upper margin only slightly arched. Hinge unknown.

Measurements (in millimetres).

	Holotype.	Paratype.
Total length	73·5	65·7
Maximum height	36·8	31·8
Maximum thickness	21·6	20·4

Locality.—The two specimens of which the larger and better preserved one has been selected as the holotype of the species, were collected by Mr. N. C. Mittal from the Siwalik rocks near Nagrota, about 7 miles from Jammu. From the type of the two species of Unionids before me, I am of opinion that the Nagrota rocks are not older than the Upper Siwalik period.

Remarks.—The species is closely allied to the recent *L. marginalis* (Lam.), but is distinguished from its various forms by its shape, the very marked posterior wing and the very rostrate posterior margin.

Genus : INDONAIA Prashad.

1918. *Indonaia*, Prashad, *Rec. Ind. Mus.*, XV, pp. 146-148.

A fossil species of this genus was described by Vredenburg and Prashad[2] from the lowermost strata of the Irrawadi series at

[1] Annandale, N. *Rec. Geol. Surv. Ind.*, LV, pp. 103, 104, pl. vi, figs. 2, 2a (1923).
[2] Vredenburg, E. and Prashad, B. *Rec. Geol. Surv. Ind.*, II, pp. 372, 373, pl. xii, figs. 3, 9 (1921).

Chaunggyauk, Burma, under the name *I. glyptica*, and a fossil from the Oil-Beds of the Dawna Hills, Tenasserim, was rightly identified by Annandale[1] with the recent species, *I. bonneaudi*, (Eydoux). In the collections before me there are two new species of the genus from such widely separated areas as Jammu on the one hand, and Hyderabad (Deccan) on the other.

INDONAIA MITTALI, sp. nov.

(Pl. 25 figs. 2, 3.)

This species is described from two specimens with the shell valves closely united. It is not possible, therefore, to describe the hinge in this species, but from the general facies of the shell I have no doubt that it is a form of the genus *Indonaia*.

Shell of medium size; solid; triangular to subrhomboid; inflated, inequilateral, umbones full, inflated, almost meeting in the middle line, eroded; posterior ridge low; ventral margin greatly arched more so posteriorly than anteriorly; anterior margin evenly curved; posterior margin narrow, drawn out into a beak-shaped area; dorsal slope greatly arched; surface with well marked lines of growth. Hinge unknown.

Measurements (in millimetres)

	Holotype.	Paratype.
Total length	40·0	33·8
Maximum height	26·4	21·2
Maximum thickness	19·1	18·9

Locality.—Two specimens of this species were received by the Geological Survey of India from Mr. N. C. Mittal after whom the species has been named. They were collected from the Siwalik rocks near Nagrota about 7 miles from Jammu with the shells of *L. jammuensis* described above.

Remarks.—The species is allied to the widely distributed recent Indian species *I. cærulea* (Lea)[2], but is distinguished by its peculiar form, the very raised umbonal area and the very elongate posterior margin.

[1] Annandale, N. *id. ibid.*, p. 102, pl. vii, figs. 6, 7.
[2] Preston, H. B. *Faun. Brit. Ind. Freshw. Moll.* pp. 136, 137 (1914).

It is also of interest to note that no recent species of the genus *Indonaia* are known from the Punjab to the north of the basin of the Sutlej River.

INDONAIA PASCOEI, sp. nov.

(Pl. 25 figs. 4, 5.)

At the request of the discoverer of this species, Mr. K. A. Knight Hallowes, formerly Assistant Superintendent in the Geological Survey of India, I have associated this Unionid with the name of Dr. E. H. Pascoe, Director of the Geological Survey.

The species is described from a conglomerate consisting almost entirely of fossilized shells. Dr. J. Coggin Brown at my request tried to get some of the shells separated for studying the hinge teeth, but owing to the greatly compressed shells and the brittle nature of the fossils the results were far from satisfactory.

Shell ovately-rectangular, slightly curved, moderately solid; concentrically striate; umbones small, distinct but not prominent; dorsal margin slightly arched; ventral margin nearly straight; anterior side slightly produced and sharply rounded; posterior side obtusely rostrate, sloping steeply above, then rounded; posterior ridge distinct, but not sharp.

In the various fragments the hinge teeth, so far as they could be made out, resemble those of the other species of the genus.

Measurements (in millimetres).

	Holotype.	Paratypes.	
Total length	43·5	41·2	41·6
Maximum height	26·6	24·9	25·2
Maximum thickness	14·4 single valves only.		

Locality.—The following note as to the locality, horizons, etc., was supplied by Mr. K. A. Knight Hallowes :—" In large numbers in a thin lenticular bed of pale calcareous Lameta shale, resting directly upon calcified hornblende granite gneiss of Archæan age, and covered by the Deccan Trap series (Upper Cretaceous or Lower Tertiary), at a point situated 2 furlongs S. 10° W. of Nawapet (17° 43′ 30″ 78° 23′ 45″), Hyderabad State (Deccan)."

Remarks.—*I. pascoei* is allied to *I. shurtleffiana* (Lea)[1], but is distinguished by its larger size, different shape, the very short anterior region and the position of the umbones.

Genus : PARREYSSIA Conrad.

(Pl. 25 figs. 6, 8.)

A few imperfect specimens of a Unionid from the Upper Siwaliks at Khanpur, Jammu, are referrable to this genus. They resemble the recent *P. corrugata* (Müller)[2], and I have no doubt that they represent a form of this highly variable and widely distributed species. I figure two of the fossil shell valves, and a portion of a valve which shows the umbonal sculpture.

It is of interest to note that like the genus *Indonaia* no recent species of the genus are known to the north of the basin of the river Sutlej in the Punjab.

[1] Lea, I. *Proc. Acad. Nat. Sci. Philadelphia,* VIII, p. 94 (1856), and Simpson, C. T. *A Descriptive Catalogue of the Naiades etc.*, pp. 983, 984 (Detroit, 1914).

[2] *See* Preston, H. B. *op. cit.* pp. 154, 156 and Simpson, C. T. *op. cit.* pp. 1105, 1107.

EXPLANATION OF PLATE 25.

All the figures are reproduced natural size, from direct photographs of the specimens.

FIG. 1.—Holotype of *Lamellidens jammuensis,* sp. nov. from near Nagrota, Jammu.

FIGS. 2, 3.—Holotype and paratype of *Indonaia mittali,* sp. nov. from near Nagrota Jammu.

Indonaia pascoei sp. nov.

FIG. 4.—Part of the conglomerate showing a number of complete shells from Nawapet, Hyderabad State.

FIG. 5.—Holotype of the species.

Parreyssia sp.

FIGS. 6, 7.—Two incomplete valves of two specimens from Khanpur, Jammu.

FIG. 8.—An incomplete right valve showing the umbonal sculpture.

MGIPC—M—V-2-6—6-12-27—800.

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ON THE RELATIONSHIP BETWEEN THE SPECIFIC GRAVITY AND ASH CONTENTS OF THE COALS OF KOREA AND BOKARO: COALS AS COLLOID SYSTEMS.

BY L. LEIGH FERMOR, O.B.E., D.SC., A.R.S.M., M.I.M.M., F.G.S., *Officiating Director, Geological Survey of India.* (With Plates 26 and 27.)

CONTENTS.

I.—INTRODUCTION.

WHEN making an examination of a mineral deposit in order to determine the economic value thereof, one of the most important tasks before the geologist or mining engineer is to take average

specimens of coals from the Kurasia coalfield, Korea State.

Predicted ash contents (6—1·28) × 100.	Error of prediction (10—7) or deviation from standard (1·28).	Caking properties.	Colour of ash.	Description of specimens.	Classification.
10	11	12	13	14	15
2	+1	Sinters slightly .	Buff . .	Bright coal layers	First-class coals.
8	—1	Does not cake	White . .	Dull slightly silky coal.	
17	+1	Ditto . .	Light brown .	Dullish .	Second-class coals.
15½	1	Does not cake, but sinters slightly.	Very light grey	Typical dull shale-coal.	
24	—7	Does not cake .	Light brown .	Finely banded bright & dull coal.	Third-class coals.
36	+3	Ditto . .	Brown . .	Greasy lustred shale-coal.	Fourth-class coals.
33	—2	Ditto . .	Very light brown.	Greasy lustred shale-coal.	

III.—THE COALS AND CARBONIFEROUS SHALES OF THE BOKARO COALFIELD.

On commencing work in the Bokaro coalfield at the beginning of 1916, I took an early opportunity to send typical specimens of coal to the Geological Survey laboratory in Calcutta for the determination of the specific gravity and proximate chemical composition, the whole of the material upon which the specific gravity was determined being used for analysis. This work was continued during the following field season of 1916-17. These results were required primarily to help the field work in the manner already explained: but, in addition, it was my purpose to ascertain whether in the case of the Bokaro coals a relationship between specific gravity and ash contents could be detected similar to that found to hold for the Korea coals. As a result it was found that the relationship did, in most cases, hold, and in 1919, additional specimens were selected from my collection to fill up gaps in the sequence. Specific gravity determinations and analyses were repeated on duplicate material in some cases where the results seemed to depart seriously from what might be expected. The description of each specimen was recorded before sacrificing it for analysis, and duplicate specimens were as before retained for reference.[1] The full data including the descriptions are assembled in table 2 in order of increasing ash contents. All the specimens come from the Barakar stage of the Gondwana formation and are, therefore, of Palæozoic age.

On scanning this table it will be observed that on the whole the specific gravity increases *pari passu* with the ash contents, although there are certain marked exceptions [F. 141, F. 112, F. 175 (one analysis)] that interrupt this orderly sequence, F. 141 having a specific gravity that is too high and F. 112 and F. 175 specific gravities that are too low for their place in the sequence. F. 378, F. 142 and F. 138 have also slightly high specific gravities for their position. In column 9 of the table are shown the figures obtained by subtracting from G, the specific gravity, the ash contents divided by 100; in other words, the figures in column 9

$$= G - \frac{\text{ash contents}}{100}$$

[1] The analyses and specific gravity determinations of the Korea specimens were made by Mahadeo Ram, and of the Bokaro specimens mainly by Mahadeo Ram and Baroda Charan Gupta.

TABLE 2.

Analyses, specific gravities, and descriptions, of hand-specimens of coal and carbonaceous shales from the Bokaro Coalfield.

TABLE 2.—*Analyses, specific gravities, and descriptions, of hand-specimens*

1	2	3	4	5	6	7	8	9	10
Field number of specimen.	Rock register number.	Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Specific gravity (G).	$G - \frac{ash}{100}$	Deviation from standard (1·26).
F. 377* .	23·096	Seam 13, Joint Railway colliery.	1·99	27·47	68·23	2·31	1·28	1·26	0
F. 377† .	23·996	Ditto . .	1·21	27·76	68·53	2·50	1·28	1·255	0
F. 114* .	23·926	Seam 13, Sawang . .	2·24	29·83	64·32	3·61	1·30	1·26	0
F. 116* .	23·928	Ditto . .	1·53	29·72	61·50	7·25	1·33	1·26	0
F. 378* .	23·997	Seam 4, Jharna Nala .	0·71	18·84	71·99	8·46	1·38	1·30	+4
F. 379* .	23·997	Seam 7, Ditto .	1·12	22·69	62·80	13·39	1·39	1·26	0
F. 109* .	23·921	Seam 13 (pit), Sawang .	1·00	29·74	55·40	13·86	1·41	1·27	+1
F. 109‡ .	23·921	Ditto .	1·16	26·82	53·60	18·42	1·42	1·24	—2
F. 109* .	23·921	Ditto .	1·30	24·56	52·35	21·79	1·48	1·26	0
F. 169† .	—	Seam 8, Gobindpur .	0·40	19·98	57·44	22·18	1·51	1·29	+3
F. 141‡ .	23·945	Seam 9, Sasbehra Garha (trench).	0·60	20·57	54·38	24·45	1·58	1·34	+8
F. 141* .	23·945	Ditto . .	1·19	20·66	52·27	25·88	1·63	1·37	+11
F. 168† .	—	Seam 8, Gobindpur .	0·50	21·41	51·23	26·86	1·53	1·26	0
F. 112* .	23·924	Seam 13, Sawang . .	1·60	25·83	44·96	27·61	1·40	1·21	—5
F. 159a†	23·954	Trench, tributory of Sasbehra Garha.	0·48	22·61	49·17	27·74	1·54	1·26	0
F. 141† .	23·945	Seam 9, Sasbehra Garha (trench).	0·43	24·61	45·81	29·15	1·63	1·34	+8
F. 142† .	23·946	Ditto . .	0·48	21·00	48·05	30·47	1·60	1·30	+4
F. 139† .	23·943	Seam 9, Sawang (pit 3) .	0·57	20·67	45·83	32·93	1·59	1·26	0
F. 138† .	23·942	Ditto . .	0·57	17·41	25·91	36·11	1·66	1·30	+4
F. 175* .	23·966	Seam 15, Sawang (D. B. H. V.)	0·98	22·05	37·60	39·37	1·65	1·26	0
F. 175† .	23·966	Ditto . .	0·86	22·69	32·89	43·56	1·57	1·13	—13
F. 167† .	23·962	Seam 8, Gobindpur .	0·40	16·29	38·79	44·52	1·72	1·27	+1
F. 140† .	23·944	Seam 9, Sawang (pit 3) .	0·58	19·18	31·24	49·00	1·77	1·28	+2
F. 364* .	23·984	Jharna Nala . .	1·47	16·93	27·20	54·40	1·86	1·32	+6
F. 175* .	23·966	Seam 15, Sawang (D. B. H. V.)	1·76	15·86	26·03	56·35	1·86	1·30	+4
F. 111* .	23·923	Seam 13, Sawang (pit 1)	1·57	17·31	19·17	61·95	1·98	1·36	+10
F. 181* .	23·972	Godo Nala, Bermo .	1·08	12·11	20·19	66·62	2·01	1·34	+8
F. 181† .	23·972	Ditto . .	0·91	9·92	20·64	68·53	2·03	1·34	+8
F. 64§ .	—	Montiko Nala . .	0·85	7·87	17·32	74·12	2·19	1·45	+19
F. 170† .	23·963	Seam 8, Gobindpur .	0·51	11·57	0·51	87·41	2·58	1·71	+45

NOTES.—1. These analyses were made by Mahadeo Ram (*), Baroda Charan Gupta (†), Bengal Iron

2. All these localities are in East Bokaro (the section of the field east of Lugu Hill), except those of in cases where the data were been correlated with those of East Bokaro. Seam 13 in East Bokaro is the well-known Kargali

of coal and carbonaceous shales from the Bokaro coalfield.

11	12	13	14
Caking properties.	Colour of ash.	Description of specimens.	Classification.
Cakes strongly .	Yellow	Bright coal substance with few minute dull laminae.	
Ditto . .	White	Ditto	
Ditto . .	Do.	Bright coal substance	
Ditto . .	Do.	Silky coal with bright bands	First-class coals.
Cakes . . .	Do.	Ditto	
Cakes strongly .	Do.	Silky coal with numerous thin bright bands .	
——	——	Silky coal with some bright bands . . .	
Cakes strongly .	Brownish white .	Silky coal with some bright bands	
Cakes, but not strongly.	White	Ditto with bright bands removed . .	Second-class coals.
Cakes . . .	——	Satiny coal with bright laminae and veinlets .	
——	——	Granular, banded, semibright coal	
Does not cake .	Dark reddish brown	Ditto	
Cakes . . .	——	Stone coal, finely laminated bright and dull .	
Cakes strongly .	Buffish white .	Shaly coal (banded bright and dull) . .	Third-class coals.
Do. feebly . .	——	Laminated satiny coal	
Cakes . . .	Dark grey . .	Granular, banded, semi-bright coal . . .	
Do.	Grey	Finely laminated dull and bright . . .	
Do. . .	Do.	Black silky coal with fine lamination . .	
Do.	Do.	Dull silky grey coal with bright veinlets . .	
Cakes strongly	Greyish white .	Dull greasy-lustred coal approaching shale .	
Cakes . . .	——	Ditto	Fourth-class coals.
Do. . . .	——	Dull grey coal with thin bright bands . .	
Do.	Light grey . .	Laminated dull coal with bright streaks . .	
Does not cake .	Light buff . .	Carbonaceous shale	
Ditto . .	Light yellow . .	——	Coaly shales and carbonaceous shales.
Ditto . .	White	Shaly coal (or carbonaceous shale with thin bands of bright coal).	
Ditto . .	Very light yellow .	Coaly m. c. shale	
Ditto . .	——	Ditto	M. c. shales (micaceous carbonaceous shales).
——	——	Micaceous carbonaceous shale (M.c. shale) .	
——	——	Ditto ditto . . .	

Co. (‡) and C. S. Fawcitt (§). Specific gravity determinations by the analysts. Blanks are shown in columns 11 and 12 not recorded by the analysts.
F. 378, F. 379, and F. 364, Jharna Nala, which is in West Bokaro. The numbers of the West Bokaro seams have not seam.

Considering for the present only those analyses showing less than 50 per cent. of ash, that is those that can properly be called coals (see column 14 of the table), we find that for 17 specimens, each represented by 1 or more analyses, in no less than 9 cases does this figure come to 1·26. The difference in each case of the figure so obtained from 1·26 is shown in column 10 of table 2, each unit representing 0·01. These *deviations*, as I propose to call them, may be summarised as follows :—

Amount of deviation (unit = 0·01)	No. of cases
—13	1
— 5	1
— 2	1
0	10
+ 1	2
+ 2	1
+ 3	1
+ 4	3
+ 8	2
+11	1

1·26 is therefore adopted as the *fundamental specific gravity of pure ash-free Bokaro coal* and the deviations from this figure ranging from —2 to +4 above are not thought to need any particular explanation. But some explanation of the two low specific gravities and the three high ones appears desirable.

My first thonght was that there might be some inherent difference between the carbonaceous material of these exceptional coals and that of coals of more normal density. First, however, I had F. 175 re-analysed, as an example of unusually low density (—13), and F. 141 as an example of unusually high density (+8). F. 175, on re-analysis, gave the upper of the two analyses shown in table 2 and the correspondence here for ash and density is so good that $G - \frac{ash}{100} = 1{\cdot}26$; so that we are compelled to assume that there is some error in the first determination either in the analysis or in specific gravity. The other low example (—5) has not been retested. A possible explanation of this deviation is given on page 334.

Coming now to the high figures, F. 141 with a deviation of +8 was re-analysed and found to give a deviation of +11, so that evidently this high figure is not due to any error, but is particular to this coal.

Dr. Fox suggested to me that the departure of some of these coals from my rule might be due not so much to differences in the character of the carbonaceous substance as in the composition of the ash. To test this I selected three specimens, namely, one Korea coal conforming to rule (K.3; +1), one Bokaro coal conforming to rule (F.109; 0 and —2), and the high gravity Bokaro coal (F. 141; +8 and +11). At Dr. Fox's request, Mr. Dawes Robinson, Chief Chemist to the Bengal Iron Co., Ld., very kindly had the ash of these three specimens analysed in his laboratory. The results are as follows:—

TABLE 3.—*Analyses of ash of coals from Korea and Bokaro.*

Coalfield.	Kurasia field, Korea.	Bokaro.	
Number of specimen.	K.3: 27/433.	F.109: 23·921	F.141: 23·945
Specific gravity (G)	1·448	1·409	1·585
Proximate analysis:—			
Moisture	4·80	1·00	0·60
Volatile matter	27·09	29·74	20·57
Fixed carbon	52·40	55·40	54·38
Ash	15·71	13·86	24·45
	100·00	100·00	100·00
Analysis of ash:—			
SiO_2	61·20	52·40	32·60
Al_2O_3	32·19	41·09	42·35
Fe_2O_3	3·71	3·71	16·86
CaO	0·40	1·60	4·20
MgO	2·37	0·79	2·37
SO_3	0·09	0·09	0·08
P_2O_5	0·09	0·09	1·59
	100·05	99·77	100·05
$G - \frac{\text{ash}}{100}$	1·27	1·27	1·34
Deviation from standard*	—1	+1	+8

* 1·28 for Korea, 1·26 for Bokaro.

From these analyses it will be seen that the first two are normal coals with specific gravity conforming closely to the rule, but that the third analysis with a deviation from the standard of +8 confirms the two previous analyses of F. 141. The reason is seen to lie, as Dr. Fox suggested, in the different compositions of the ash. K. 3 and F. 109 have identical ferric oxide (3·71 per cent.) and nearly identical total silica plus alumina (93 per cent.). F. 141, the abnormal coal, has nearly 17 per cent. of ferric oxide and only 75 per cent. of silica plus alumina. We see now that F. 141 owes its high specific gravity to unusually high contents of iron oxide—amounting to over 4 per cent. of the weight of the coal.

We may, I think, legitimately deduce from these figures that the rule we have discovered connecting specific gravity and ash contents of Korea and Bokaro coals applies particularly to cases where the ash content is mainly comprised of silica and alumina (in fact dehydrated clay) with only low iron contents; and that a high density relative to that required by our rule indicates an ash of higher density than usual, no doubt almost always due to the presence of a compound of iron, which I have, indeed seen on several occasions as red spots of hematite in certain Bokaro coals.

We have now explained the three high positive figures above the 50 % ash line in table 2: the colour of the ash recorded in two cases—dark reddish brown and dark grey (? reducing atmosphere)—may be taken as concordant. If the smaller figures of +4 recorded in three cases are due to a small excess of iron oxide the amount does not appear to have been enough to affect the recorded colour of the ash.

The seriously large negative figure (—13) has been explained as probably due to an error and we can therefore confidently adopt our rule for future use.

The rule is that for Korea and Bokaro coals (Barakar series) there is a definite numerical relationship between ash contents and specific gravity. If g denote the specific gravity of the coal, a the ash contents, and k the specific gravity constant of pure coal, then

$$g - \frac{a}{100} = k,$$

$$\text{or } a = 100\,(g - k).$$

For Korea coals $k = 1{\cdot}28$; for Bokaro coals $k = 1{\cdot}26$. For each field k should be separately determined, but in cases where this

has not been done it would perhaps be better to use the Bokaro constant, because it is based on a much larger number of analyses than the Korea constant.[1]

The constant can, however, be determined quickly and directly by picking out as pure a specimen of bright coal as possible, and sending it to a laboratory for proximate assay and specific gravity determination on the same material.

In Plate 26 both the Korea and Bokaro results are plotted to scale, with specific gravities as ordinates and ash contents as abcissæ, the points representing the Korea data being distinguished by circles. Discussing only the Bokaro data and confining ourselves as hitherto to coals (up to 50 per cent. of ash) we see that the majority of the results conform quite closely to a straight line law with origin at 1·26. The three points that lie some distance above this line (ash 24 to 29 per cent.) represent the three analyses of the high-iron coal F. 141. The one spot rather far below is the

[1] That the values of this constant adopted for Korea and Bokaro coals respectively differ may be due to the fact that the Korea figure is based on only 7 analyses. But consideration of the Korea data given in table 1 makes one prefer to adopt the view that the difference actually exists. The curious point then is that the coals with the higher moisture, namely those of Korea, have the higher fundamental specific gravity instead of the smaller. This suggests a parallel relationship between moisture contents and specific gravity, a suggestion that receives support from data representing two specimens of coal collected by me in the Island of Skye some years ago. The proximate analyses and specific gravities are given in the following paper (p. 359), from which it will be seen that with moisture contents still higher than that of the Korea coals, the Skye coals give also a higher specific gravity constant for pure coal, namely 1·30 and 1·32, or a mean of 1·31. It is true that the colour of the ash is recorded as light brown and brown respectively, but the total percentage of ash is small, and calculation shows that using the ash percentage and specific gravity figures actually determined the values of k calculated from the first coal are 1·313 and 1·303 according as the specific gravity of the ash contents be taken as 3·0 and 5·0. The facts for the three sets of coals may be summarised as follows :—

Locality.	Number of analyses.	Moisture.		Specific gravity constant (k).
		Range.	Average.	
Bokaro	23	0·40— 2·24	0·95	1·26
Korea	7	3·47— 9·80	5·58	1·28
Skye	2	11·41—11·72	11·56	1·31

The significance of this parallel relationship is discussed in Section VIII of this paper.

—5 coal F. 112. The Korea coals are also sufficiently close to the upper straight line with origin at 1·28 except the —7 coal No. G.N.

We may say then that for coals (as distinct from carbonaceous shales) the diagram shows that for all practical purposes we may accept a straight-line law for the relationship between ash contents and specific gravity as is required by the formula already empirically deduced above.

Let us return now to our table No. 2 and consider the analyses corresponding to carbonaceous substances with more than 50 per cent. of ash — carbonaceous shales of various sorts in fact. From column 9 it will be seen that they invariably show a positive deviation from the standard specific gravity when treated according to the rule, and that on the average this deviation increases rapidly with increasing ash contents so that with 66 per cent. of ash it is +8, with 74 per cent. it is +19 and with 87 per cent. it is +45. The beginning of this deviation was perhaps indicated by the last two coals with deviations of +1 and +2 respectively, but these deviations may be only conformable in significance with those shown higher up on the list of coals. On referring again to our diagram it will be seen that on plotting these density-ash values for the carbonaceous shales we find that the curve is no longer a straight line.

If we assume that the last determined point on our curve, with $G = 2{\cdot}58$, 87·4 per cent. of ash and 12·6 per cent. of total volatiles, is a simple mixture of shale of $G = x$ and coal substance of $G = 1{\cdot}26$, then we find that the specific gravity of the shale portion is 3·04. This is, of course, a high figure for shale, but it gives us a maximum point for the termination of our curve on the ordinate corresponding to 100 per cent. of ash.

IV.—EXPLANATION OF THE EMPIRICAL DENSITY-ASH RULE.

It appears then that we have discovered an empirical rule connecting the specific gravity of coal and its ash contents that applies closely to coals containing up to 50 per cent. of ash, but which does not apply to the carbonaceous substances containing over 50 per cent. of ash, *i.e.*, to carbonaceous shales. It is desirable, if possible, to discover the reason for this empirical rule and its limitations, and also what is the theoretical rule.

Let us investigate the case of a series of mixtures of pure coal of specific gravity k (our constant) with a non-carbonaceous diluent,

which we may regard as shale of specific gravity s. As before, g stands for the specific gravity of the impure coal or carbonaceous shale and a for the percentage of ash or shale in the coal or carbonaceous shale. It is evident that

$$\frac{a}{s} + \frac{100-a}{k} = \frac{100}{g}, \qquad (1)$$

from which we find that

$$s = \frac{akg}{ag-100\,(g-k)}. \qquad (2)$$

We can now consider three cases. The first is that in which our empirical rule

$$a = 100\,(g-k) \qquad (3)$$

is assumed to hold for the whole range from 0 to 100 per cent. of ash or shale. Substituting this value of a in equation (2), we find that

$$s = \frac{kg}{g-1}. \qquad (4)$$

The following table shows the values of g and s for each 10 per cent. of ash from 0 to 100:—

a	g	s	a	g	s
0	1·26	6·11	50	1·76	2·92
5	1·31	5·33	60	1·86	2·73
10	1·36	4·76	70	1·96	2·57
20	1·46	4·00	80	2·06	2·45
30	1·56	3·51	90	2·16	2·35
40	1·66	3·17	100	2·26	2·26

It is obvious that the specific gravity of the diluent 'ash' cannot vary continuously (from 6·11 to 2·26) with the percentage present. Nevertheless the relation

$$a = 100\,(g-k)$$

is found empirically to hold over the range of ash contents from 0 to 50 per cent., as if, therefore, the density of the ash does range from 6·11 to 2·92. The figures in the above table have, therefore, been plotted as the curve CE in Plate 27. We shall see later what significance they have.

The second case is that in which our empirical rule (3) is still assumed to hold for the whole range from 0 to 100 per cent. of ash or shale, but in which we allot a constant value to the specific gravity s of the ash or shale, and investigate what variations in the specific gravity of the organic matter are necessary to give the linear rule. Taking v as the specific gravity of the organic matter (vitrain[1] + vegetable detritus) and substituting it for k in equation (1), we find that

$$v = (100—a) \times \frac{gs}{100\ s—ag};$$

and substituting the value of a according to equation (3),

$$v = \frac{gs\ [\,1—(g—k)]}{s—g\ (g—k)}$$

The following table shows the value of g and v for each 10 per cent. of ash from 0 to 100 (1) if s=2·6, and (2) if s=3·0 :—

$s = 2·6$			$s = 3$		
a	g	v	a	g	v
0	1·26	1·26	0	1·26	1·26
5	1·31	1·277	5	1·31	1·272
10	1·36	1·292	10	1·36	1·282
20	1·46	1·316	20	1·46	1·294
30	1·56	1·332	30	1·56	1·294
40	1·66	1·338	40	1·66	1·279
50	1·76	1·330	50	1·76	1·245
60	1·86	1·304	60	1·86	1·185
70	1·96	1·245	70	1·96	1·083
80	2·06	1·125	80	2·06	0·914
90	2·16	0·856	90	2·16	0·614
95	2·21	0·574	95	2·21	0·368
100	2·26	0	100	2·26	0

Taking $s = 3$, the corresponding values of v have been plotted as the curve AK in Plate 27. As the linear rule holds only over the range of ash contents from 0 to 50 per cent., we are concerned only with the range of density of the organic matter from 1·26 through 1·294 to 1·245. If the organic matter could be regarded as composed of vitrain only, we could hold, as with the ash, that the specific gravity of the vitrain could not vary continuously with the percentage present. But the organic part of this coal probably contains two types of substances, namely, vitrain and vegetable detritus

[1] See Section VI, page 336.

(see p. 344), and if the latter had a higher specific gravity than the vitrain, then the specific gravity of the two should increase with increase in the percentage of vegetable detritus. This assumption would not, however, explain the subsequent decrease in specific gravity, and consequently again it seems necessary to deduce that the specific gravity of the organic portion of the coal does not change continuously with the percentage thereof present.

The third case is that in which we assume that the various coals and carbonaceous shales may be regarded as mechanical mixtures of pure coal of specific gravity k and shale of specific gravity s. From equation (1) it is evident that

$$g = \frac{100}{\frac{a}{s} + \frac{100-a}{k}} \qquad (5)$$

Assuming various values for s, the specific gravity of the admixed ash or shale, we can calculate the specific gravities of coals and carbonaceous shales ranging from 0 to 100 per cent. of ash or shale, and compare the results with those required by the empirical rule and with those actually determined by experiment. These values have been calculated for the values of s from 2·6 to 3·1. It is unnecessary to print them here, but the deviations of the figures so calculated from the specific gravity figures required by the empirical rule are shown in table 4 on the next page.

We have to decide which of these calculated sets of deviations agrees best with the facts. Our curve OB in Plate 26 expresses the smoothed results of experiment, and from this have been taken the figures given in column 8 of our table 4.

On comparing the deviations given in column 8 with the deviations for various assumed specific gravities of admixed ash or shale, we observe that the closest agreement is with the deviations for $s = 3{\cdot}0$. This we might have anticipated, as our curve OB in Plate 26 terminates at about 3·04 for 100 per cent. of ash. 3·0 is a high figure for the specific gravity of ordinary shale, but it is that which suits best our data. In Plate 27, I have, therefore, inserted the curve AF showing the specific gravities for admixtures of pure coal of $k = 1{\cdot}26$ and pure ash or shale of $s = 3{\cdot}0$. It will be seen from the diagram that this curve AF cuts the curve AE representing our empirical rule at H corresponding to about 45 per cent. of ash. There is not room to re-plot on this figure the curve OB of Plate 26

TABLE 4.—*Deviations of calculated specific gravities of coal and carbonaceous shales, with different assumed specific gravities of admixed ash or shale, from specific gravities required by the empirical straight-line rule.*

Percentage of ash.	Assumed specific gravity of ash or shale.						Deviations measured from curve O B in figure 1.
	2·6	2·7	2·8	2·9	3·0	3·1	
0 . .	0	0	0	0	0	0	0
5 . .	—2	—1½	—1½	—1	—1	—1	0
10 . .	—3	—3	—3	—2½	—2	—2	0
20 . .	—5½	—5	—4½	—4	—3½	—3	0 (—2)
30 . .	—7	—6	—5	—4	—3	—3	0 (—5)
40 . .	—7	—6	—4	—3	—2	—1	0
50 . .	—6	—4	—2	0	+2	+3	+2
60 . .	—4	—1	+2	+5	+7	+10	+6
70 . .	+1	+6	+9	+13	+16	+19	+13
80 . .	+8	+13	+19	+24	+29	+34	+29
90 . .	+19	+26	+34	+41	+48	+55	+50
100 .	+34	+44	+54	+64	+74	+84	+78

NOTE.—Units of deviation represent 0·01.

representing the experimental facts. But if so plotted it would coincide throughout neither with the theoretical curve AF (based on s = 3·0) nor the empirical curve AE. Above 45 per cent. of

ash it would, it is true, coincide almost exactly with the portion HF of the curve AF, but below 45 per cent. it would coincide with the portion AH of the curve AE.

The agreement of facts with the curve AF above 45 per cent. of ash indicates that above this point we are dealing with mechanical mixtures of coaly matter and shale. One would have expected, therefore, that the data would continue to agree with the curve AF below 45 per cent. The fact that in the majority of cases they do not must have some significance. One possibility is that below 45 per cent. of ash the specific gravity of the ash conforms to the curve CE. This seems inherently improbable, especially in view of the ash compositions given in table 3. We must accept the likelihood, therefore, that the specific gravity of the ash of coals with less than 45 per cent. of ash is not in normal cases higher than that of coals and carbonaceous shales above 45 per cent. of ash. Another possibility, namely that the specific gravity of the organic portion of the coal might vary according to the curve AK, has already been rejected. Our facts appear then to prove that the ash contents of coals with less than 45 per cent. of ash is not present, at least entirely, in mechanical admixture with the carbonaceous matter: instead they appear to prove that *the association of carbonaceous matter and inorganic matter is accompanied by decrease of volume, suggesting that at least a portion of the ash contents of such coals is in chemical or physical association with the carbonaceous matter.* In section VIII of this paper it is suggested that the data are explained adequately by the assumption that the particular form of association is colloidal; decrease of volume is a characteristic of many colloidal systems.

V.—SIGNIFICANCE OF THE EMPIRICAL RULE: CONTAINED INORGANIC MATTER PARTLY IN CHEMICAL OR PHYSICAL ASSOCIATION WITH THE COAL.

It is not possible from this statistical investigation to show whether the whole of such inorganic matter is in such colloidal association, or only a portion. But the space between the two curves AF and AE between the points A and H is a measure of the condensation that has accompanied the admixture or association of carbonaceous matter and inorganic matter, and if with the lower-ash coals all the inorganic matter is in colloidal asso-

ciation with the organic matter, it seems likely that with the decreasing total condensation indicated for ash contents in excess of 30 per cent. ($s = 3 \cdot 0$) to 40 per cent. ($s = 2 \cdot 6$), the proportion of inorganic matter in colloidal association with organic matter progressively decreases.[1] If it be objected that the specific gravity of admixed shale upon which the curve AF is based, namely 3·0, is too high for normal shale, the answer is that if a lower figure be selected, say 2·6, the space separating the two curves AF and AE between the points A and H becomes wider, indicating a still greater degree of condensation.

Attention may now be redirected to the two analyses (F. 109 and F. 112) in table 2 showing minus deviations from the rule. These deviations have been inserted in brackets in column 8 of table 4. It will be seen that they occur at points corresponding roughly with the maximum minus deviations for calculated mixtures. These analyses have not been repeated; but it seems possible that such deviations may not be errors, but may indicate instead coals in which admixture of carbonaceous and inorganic matter has not been accompanied by reduction of volume. The —7 Korea coal with 30·60 per cent. of ash may also be cited.

From Plate 27 we see that even if our coals conformed to the curve AF below the point H as well as above it, their density-ash relationships would be sufficiently close to those pertaining to our empirical rule for the latter to be of practical value for coals as distinct from carbonaceous shales. Actually we see that the empirical rule appears to be the closer to the truth for the range 0 to 45 per cent. of ash, indicating the colloidal association between the carbonaceous and inorganic matter discussed in Section VIII.

In my memoir on the coal deposits of Korea, I suggested that[2] 'The *bright coal* is the purest, and, judging from its brilliant conchoidal fracture, is of the nature of a colloidal[3] substance which has in some way segregated chemically from the admixed earthy materials that give rise to the greater proportion of the ash of the coal.'

[1] In other terminology, we may be approaching the concentration limit of ash as the disperse phase.

[2] *Mem. G.S.I.*, XLI, p. 180, (1914).

[3] This was not, I find, the first suggestion of the colloidal nature of the bright coal substance. H. Potonié noted the colloidal nature of humus in his work 'Die rezenten Kausto-biolithe u. ihre Lagerstätten', *Abhandl. d. K. Preuss. Geol. Landesanstalt*, Neue Folge, Heft 55, II, p. 3, (1911).

Stopes and Wheeler in their paper on the 'Constitution of Coal', Depart. of Scientific & Industrial Research, p. 19, (1918), mention H. Winter as believing in the colloidal nature of coal, quoting *Glückauf*, Vol. 49, pp. 1406-1413, (1913).

The view that this bright coal is a colloidal substance seems now to be meeting with general acceptance[1] and many close observers of coal must be prepared to accept the idea that such coal has clarified itself by chemical segregation. In the same memoir (*l.c.*, p. 187) I give a case of the formation within bright layers of coal of concretionary segregations of lithomarge, and hail these as giving force to the view that the bright coal has been formed by colloidal segregation. This observation concerning lithomarge is of special interest to us now as showing that during the formation of coal, mineral matter may itself be in a state of sufficiently fine subdivision[2] to enable it—in cases where it does not segregate from the carbonaceous matter as in the Korea case just cited[3]—to enter into the intimate chemical (or physical) association with organic matter that seems to be indicated by Plate 27.

If we accept the probability that the inorganic matter in coals and carbonaceous shales may be partly present in colloidal association with carbonaceous matter and partly in mechanical admixture, then we appear to arrive at the important conclusion illustrated in Plate 27 that in coals with ash percentages of 0 to 45 colloidal association between the carbonaceous matter and the inorganic matter plays a significant part, whilst for carbonaceous shales above 50 per cent. of ash mechanical admixture predominates and colloidal association of organic and inorganic matter, if it occurs at all, is not of importance.

A reference to table 4 will show that had our curve AF in Plate 27 been based on $s = 2{\cdot}9$, which agrees nearly as closely with our experimental facts as $s = 3{\cdot}0$, the curves AF and AE would have crossed at 50 per cent. of ash. It appears, therefore, that in selecting 50 per cent. of ash as the dividing point between coal and shale (see p. 328 and diagram, Plate 26) we have selected on arithmetical grounds a point which agrees closely with that marking a significant difference between most coals and most carbonaceous shales, namely colloidal association of organic and inorganic matter in the one case and mechanical admixture thereof in the other.

[1] See, *e.g.*, R. H. Bogue, 'The Theory and Application of Colloidal Behaviour', Vol. II, p. 511, (1924).

[2] On high degree of dispersity in the terminology of colloid chemistry.

[3] And is not already in chemical combination with residual plant tissues.

VI.—NOMENCLATURE OF COALS.

In column 13 of table 2, I have entered the descriptive name attached to each specimen at the time of collection, when it was examined in the freshly fractured condition in bright sunlight. It will be seen that a great variety of descriptive terms were used. A comparative examination of all these specimens shows that they can be arranged into the groups shown in the following table :—

TABLE 5.—*Grouping of Bokaro coals according to appearance, ash contents and specific gravity deviations.*

—	Field number.	Rock register number.	Ash contents.	Specific gravity deviation.	Interpretation.
I. Bright coal substance	F. 377	23·996	2·31	0	Vitrain.
	F. 377	23·996	2·50	0	
	F. 114	23·926	3·61	0	
II. Silky coal with bands of bright coal, grading into dull greasy-lustred coal without bright coal.	F. 116	23·928	7·25	0	Silky coals (durain) with macroscopically visible vitrain.
	F. 379	23·997	13·39	0	
	F. 109	23·921	13·86	+1	
	F. 109	23·921	18·42	—2	
	F. 109	23·921	21·79	0	
	F. 159	23·954	27·74	0	
	F. 139	23·943	32·93	0	
	F. 138	23·942	36·11	+4	Dull silky coal (durain) with some vitrain.
	F. 175	23·966	39·11	0	Dull greasy-lustred coal (durain).
	F. 175	23·966	56·35	+4	
III. Granular coal	F. 141	23·945	24·45	+8	Ferruginous coal of durain with vitrain.
	F. 141	23·945	25·88	+11	
	F. 141	23·945	29·15	+8	
IV. Shaly coal grading into coaly shale.	F. 112	23·924	27·61	—5	Interbanded vitrain and carbonaceous shale.
	F. 142	23·946	30·47	+4	
	F. 167	23·962	44·52	+1	
	F. 140	23·944	49·00	+2	
	F. 111	23·923	61·95	+10	
V. Carbonaceous and m.c. shales.	F. 364	23·984	54·40	+6	Carbonaceous shale (trace of vitrain in F. 181).
	F. 181	23·972	66·62	+8	
	F. 181	23·972	68·53	+8	
	F. 64	—	74·12	+19	
	F. 170	23·963	87·41	+45	

When these specimens were originally described, Dr. Marie Stopes had not proposed her four names for varieties of bituminous coal.[1] I did not myself feel any special need for such a scheme of nomenclature, but I have nevertheless attempted in the final column above to make use of her terms where possible. 'Fusain' or 'mineral charcoal' is sometimes present in films on the bedding planes of the coal, but is unimportant. Clarain I cannot identify in these coals.[2]

Groups I & II.—Bright, silky and greasy-lustred coals.

I have accepted the bright coal substance forming group I above as *vitrain* and specimen F. 175 in group II as *durain*; assuming that these identifications are correct, the remainder of the coals in group I appear to be mixtures of vitrain and durain, the macroscopically visible vitrain becoming less abundant and the durain more abundant as the ash percentage rises. Such vitrain is important in quantity only in the first two specimens. As the percentage of macroscopically visible vitrain falls, the lustre of the durain itself also gradually changes from rather bright silky to dull greasy-lustred, possibly with the decrease of microscopically present vitrain. At the same time the tint of the durain becomes less black and more grey. Thus F. 109 is blacker and more lustrous than

[1] *Proc. Roy. Soc. London*, Ser. B., Vol. XC, pp. 470-486, (1919).

[2] Judging from Dr. Stopes' descriptions, durain and clarain are only mixtures of vitrain and vegetable debris, clarain containing a larger percentage of vitrain than durain, and a smaller percentage of vegetable debris. In addition there is a difference in the character of the admixed vegetable debris, this debris in the durain containing a higher percentage of spores than that in the clarain. It seems, therefore, possible for durain to grade into clarain, the lustre becoming increasingly bright as the percentage of vitrain increases. The lustre of the duller coal separating the vitrain laminæ in specimens F. 116 and F. 379 does not however, appear to me bright enough to justify referring this coal to clarain as described by Dr. Stopes. This note is inserted because it seems to me unlikely that I have missed any constituent in the Bokaro coals that occurs in any abundance. Mr. W. Randall, however, in his study of Jharia coals, which are very similar to the Bokaro coals, evidently recognised what he took to be clarain (see *Rec. G.S.I.*, LVI, p. 223). In the table of ash contents given Jharia clarain is shown as containing from 5-15 per cent. of ash and durain as containing 20-40 per cent. of ash; if ash contents and specific gravity were the criteria for distinguishing between clarain and durain, some of the coals in my vitrain-durain series, say F.116, F. 379 and F. 109, should be termed clarain. That this would be an unsound step is indicated by referring to the table of Korea coals in which coal with as little as 9 per cent. of ash is described as 'dull, silky' and is obviously not bright enough to be termed clarain. See also page 343.

F. 175. F. 109 also shows scattered seams and specks of lustrous vitrain, whilst F. 175 shows none.

Group III.—Granular coals.

The one specimen of this type is composed as before of vitrain and durain in banded association, but breaks with a granular fracture, due perhaps to the method of distribution of the high iron contents revealed by analysis.

Group IV.—Shaly coals.

These consist of alternate bands of the bright coal substance (vitrain) and black carbonaceous shale, the former falling off in quantity as the ash content rises, so that eventually this type becomes a coaly shale. This is the type of coal or shale that forms hard bands in the Kargali coal seam (No. 13) of the Bokaro coalfield.

Group V.—Carbonaceous shales.

These grade from types with lower ash which are dead black (carbonaceous shales) into types that are slightly less black and are harder and show minute micaceous scales on the bedding planes (micaceous carbonaceous shales — *m.c. shale* for short). These shales occasionally show a trace of vitrain and by interbanding with vitrain pass into group IV. A great thickness of m.c. shale occurs a short distance above the Kargali coal seam of Bokaro.

A glance at the deviations of the specimens in these five groups from the specific gravity required by the empirical rule shows at once that they can be arranged into two sections, namely, groups I and II with zero deviations and groups III, IV and V with plus deviations. Thus it is the vitrain-durain series (groups I and II) that conforms to our empirical rule represented by the section AH of our straight line curve in Plate 27 and it is in this series that we must look for our combined or physically associated inorganic matter. Group III shows a plus deviation on account of its high iron (see p. 325). The shales of group V conform to the section HF of the

curve for mechanical mixtures in Plate 27. The shaly coals and coaly shales of group IV being composed of alternations of vitrain with a zero deviation and carbonaceous shale with plus deviations, naturally show a plus deviation also.

In the present paper we are primarily interested in the specific gravity of the pure coal substance of the various coals studied, and it appears from the deviations collected above for groups I & II that it does not matter whether the coal is vitrain, or durain, or mixtures thereof: for the fundamental specific gravity of the carbonaceous matter of all appears to be 1·26 (Bokaro), indicating that if there is any fundamental difference between these two substances, the carbonaceous matter, whether colloidal matrix, spores or woody matter, has, for practical purposes, in most cases the same specific gravity.

A study of this vitrain-durain series shows in fact that for practical purposes the coals of this series from Bokaro may be regarded as formed from the association of two apparently (macroscopically) homogeneous substances in varying proportions. One of these is the bright coal substance (vitrain) represented by specimen F. 377 with only 2·31 per cent. of ash, and the other is the dull greasy-lustred coal represented by specimen F. 175 with 39·37 per cent. of ash. This latter type is the variety termed 'shale-coal' in my Korea memoir, and 'dull greasy-lustred coal approaching shale' in table 2 of this present paper. I quote here the paragraph in my Korea memoir referring to this variety of coal (*l.c.*, p. 181):

'The dull coal tends to possess a shaly structure, and seems to gradate (see analysis of K.3, table 1, for an intermediate stage) into a stony coal-shale or *shale-coal* of very distinctive appearance. This is heavy (G = 1·64), with a grey-black colour, almost bluish in the sun, a greasy lustre and a conchoidal fracture; the general appearance is that shown by some varieties of psilomelane, except for the fact that this shale-coal is commonly thickly besprinkled with fragments of carbonised vegetable matter, and that it often shows small stringers and veinlets of bright coal. It tends to fracture into slabby pieces, but the shaly structure is not well developed. I refer to it, however, as shale-coal in this report. Its composition is well shown by the analysis of D. 154 in table I.'

This dull greasy-lustred coal is represented by three analyses in the present series, two from Korea and one from Bokaro, which are placed together in the following table :—

TABLE 6.—*Analyses of dull greasy-lustred coals or durain.*

Locality.	Korea.		Bokaro.
Number of specimen	D.154 26·639	K.2 27·432	F.175 23·966
	Per cent.	Per cent.	Per cent.
Moisture	4·10	3·80	0·98
Volatile matter	19·10	22·28	22·05
Fixed carbon	43·52	38·96	37·60
Ash	33·28	34·96	39·37
TOTAL	100·00	100·00	100·00
Specific gravity	1·64	1·61	1·65
Deviation from standard specific gravity (Korea 1·28 ; Bokaro 1·26)	+3	−2	0
Caking properties	Does not cake		Cakes strongly.

There appears to be sufficient resemblance between the physical character and proximate chemical composition of these three specimens to permit one to accept them as representing a definite type. The differences in response to caking tests may be due to the different moisture contents of the Korea and Bokaro coals or to the conditions under which the tests were carried out, and not to any important difference between the specimens from Korea and Bokaro. It may be pointed out here that all the Korea coals are high in moisture and non-caking, or nearly so, as is shown in the table of analyses on p. 318.[1]

As one of these two types, namely the bright coal, must, when pure, be practically devoid of ash contents, it follows that the dull

[1] Further, the two coals from Skye discussed in the following paper (p. 359), which show still higher moisture contents, are also non-caking. See also page 349, and footnote to page 327.

coal must contain the ash—in intimate association with the organic matter as already shown.[1]

With this dull greasy-lustred coal (omitting the enclosed macroscopically visible fragments of carbonised vegetable matter and veinlets of bright coal) and bright coal itself, we have apparently two roughly homogeneous types of coal. There is also one homogeneous type of carbonaceous shale namely that termed by me m.c. shale (micaceous carbonaceous shale) as represented by the analyses of F. 64 and F. 170 in table 2. It seems to me that the analysis of the data given on p. 336 shows that with very few exceptions the Bokaro coals and carbonaceous shales may be regarded as compounded of these three types—bright coal (vitrain), dull coal (durain) and m.c. shale—sometimes in interlamination and sometimes in more irregular and intimate association. 'Mother-of coal' or 'mineral charcoal' (fusain) may occur in any of the types in thin films. The Korea specimens collected contain only the two first types mentioned, shaly coals and carbonaceous shales being absent. In addition macroscopically visible inorganic matter may be present, *e.g.*, lithomarge concretions in Korea coal and red hematite concretions in some Bokaro specimens.

These views concerning the composition of the coals of Korea and Bokaro based solely on a study of their proximate analyses, density, and macroscopic characters, are in accord with and receive support from the work of other observers, who, studying coals of other localities, have subjected their material to microscopic and chemical examination.

Thus A. Duparque[2], applying the metallographic microscope to the study of polished and etched surfaces of coals from the north of France, arrives at the following conclusions[3]:—

'Les observations exposées précédemment permettent de conclure, qu'abstraction faite de la substance minérale qu'elle contient, la houille est formée de deux éléments microscopiques.'

[1] But although this dull coal is to the unaided eye homogeneous it cannot be regarded as a simple compound of bright coal with inorganic matter. Microscopic examination would doubtless reveal the presence of plant entities such as spores not visible to the naked eye. The associated inorganic matter may in part be the original mineral matter of the plant contained in these entities, but it is at least in part doubtless of extraneous origin and, as indicated on p. 347, in colloidal association with the bright coal substance. See also Deparque's diagram page 342.

[2] 'Les quatre constituants de la Houille du Nord de la France', *Soc. Géol. du Nord, Annales*, L, pp. 56-79, (1926).

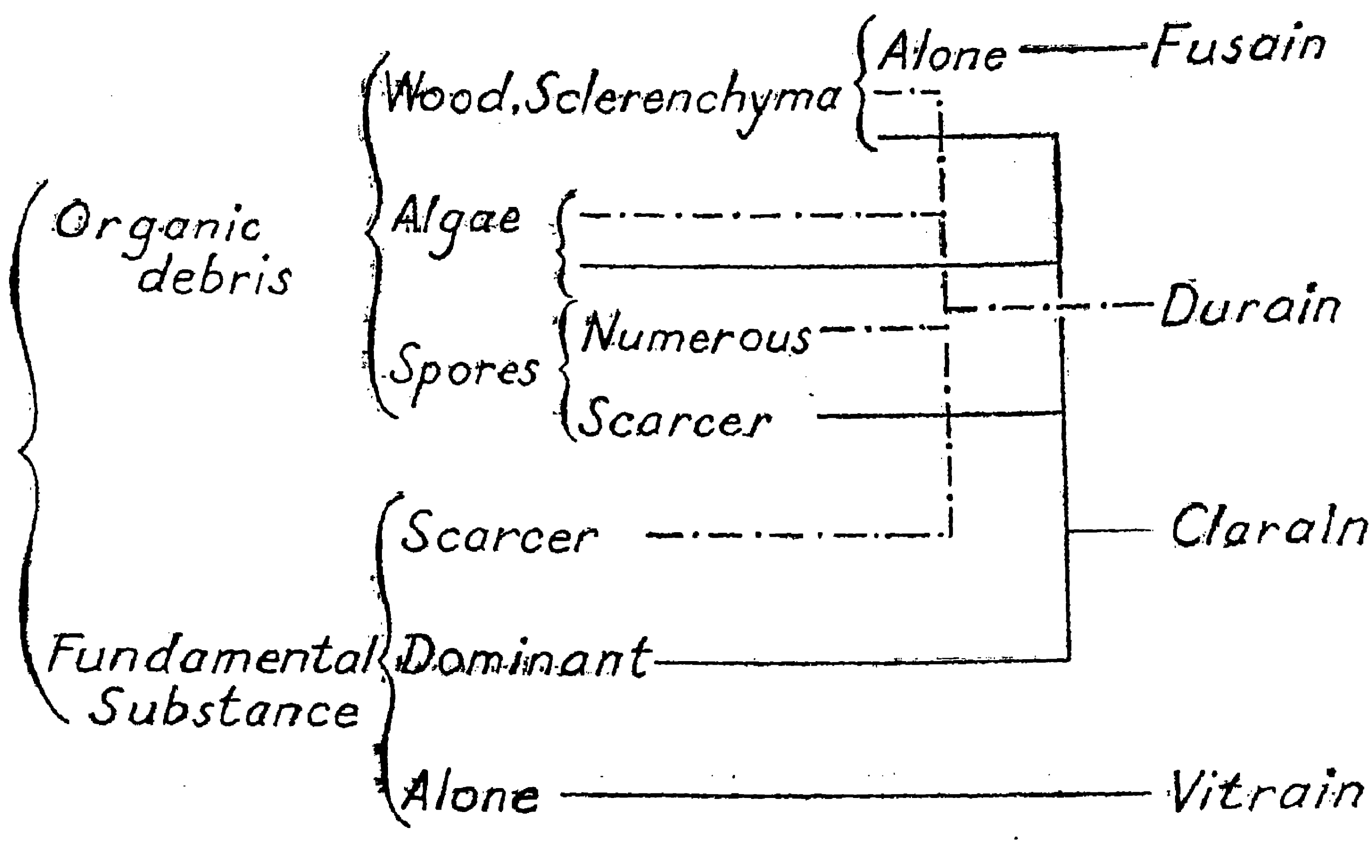
[3] *L. c.*, p. 70.

1. *Des débris végétaux* de nature différente qui se sont déposés dans un premier temps.

2. *Une substance fondamentale* de nature colloïdale qui est venue cimenter ces débris en passant successivement par les états liquide, colloïdal, puis solide, et qui dérive vraisemblablement de la dégradation ultime d'autres débris végétaux.

C'est la nature des premiers, l'absence de l'un ou de l'autre, ou leur combinaison, qui déterminent les quatre constituants macroscopiques de Mme Stopes'.

Then follow definitions of fusain, durain, clarain and vitrain and the following diagram (translated) illustrating the composition of each of these constituents :—



Vitrain, it will be seen, is identical with the 'fundamental substance.'

Professor Wheeler[1] in a paper on the 'Chemistry of Coal' read before the British Association arrives at conclusions that are practically identical with those of M. Duparque, although expressed

[1] *Journ. Soc. Chem. Ind.*, Vol. 46, pp. 848-853, (1927).

in different terms. Considering both coal and peat he states that two main types of material may be recognised :—

(*a*) ulmins

(*b*) plant materials resistant to decay and to chemical treatment.

By chemical methods it is apparently easy to effect a ready separation of the coal-ulmins from the resistant plant-debris, and thus effect a rational analysis of the several components of a banded bituminous coal. The results of such an analysis of the four component bands of Hamstead coal are given as follows[1] :—

—	Ulmin compounds.	Organised plant entities.	Hydro-carbons and resins.	General character of plant entities.
	Per cent.	Per cent.	Per cent.	
Vitrain . . .	96	Nil	4	..
Clarain . . .	92	5	3	Cuticles and spore exines.
Durain . . .	83	15	2	Cuticles, spore exines and woody tissues.
Fusain . . .	20	80	Nil	Woody tissues.

Omitting fusain as an exceptional type it is seen that vitrain and durain are the normal end types and that clarain is equivalent to a mixture of vitrain and durain—in this case roughly 9 parts of vitrain to 4 of durain—durain itself being only vitrain with admixed resistant plant debris and finely divided mineral matter.

M. Duparque's[2] diagram confirms this view of the intermediate position of clarain. These results, therefore, of Messrs. Duparque and Wheeler support the view advanced earlier in this paper for Bokaro coals that omitting the unimportant fusain of 'mineral charcoal' we have to deal, in Bokaro banded bituminous coals, only with two fundamental constituents of organic origin, namely the colloidal 'pure coal' and the vegetable detritus, which in

[1] *L. c.*, p. 850.
[2] See also Duparque, *l.c.*, Planch IV, fig. 14.

practice yield the end forms bright coal (vitrain) and greasy-lustred dull coal (durain).

In so far as the mineral matter in coal represents the ash contents of the original plants it is doubtless at least in part present in the vegetable detritus still recognisable in the coal, and to this extent the ash contents of a coal may be roughly proportional to the amount of vegetable detritus present, although it must be remembered that the formation of vitrain has involved the destruction of vegetable tissues with release of associated inorganic matter. It is doubtless in part such mineral matter that is now in intimate association with organic matter as detected in the present research. In addition, there may be 'ash' or mineral matter of extraneous origin in either the colloidal condition or in mechanical admixture. These considerations lead us to the conclusion that our banded coals are composed of four constituents, which are :—

(*a*) My 'bright coal', 'of the nature of a colloidal substance'—1914.

Dr. Marie Stopes' 'vitrain'—1919.

M. Duparque's 'Substance fondamentale de nature colloïdale'—1926.[1]

Prof. Wheeler's 'ulmin compounds' or 'ulmins' (with hydrocarbons and resins)—1927.[2]

(*b*) Vegetable detritus or organised plant entities (of which fusain may be regarded as the end form).

(*c*) Mineral matter in chemical or physical association (*e.g.* colloidal).

(*d*) Mineral matter in mechanical admixture.

In practice these four constituents give three main types of roughly homogeneous carbonaceous substances, namely :—

1. Bright coal (vitrain) composed of a
2. Dull coal (durain) composed of $a + b + c$
3. M. c. shale composed of d + (a or b).

VII.—COMMERCIAL CLASSIFICATION.

This investigation seems to throw light upon the general nomenclature of coal. It also indicates suitable lines for the classifica-

[1] For an account of the 'gelée fondamentale' of Bertrand (1898) and other French geologists, reference may be made to Stopes and Wheeler, *l.c.*, p. 31.

[2] The term 'ulmin' was proposed as long ago as 1807 by T. Thomson, and has been adopted by Stopes and Wheeler in preference to 'humic substances', *l.c.*, p. 32.

tion of Bokaro coals for commercial purposes. It is unnecessary to discuss this in detail. Reference to the tabular statement in table 2 and to the diagram forming Plate 2 indicates that the following is a suitable classification of Bokaro coals for commercial purposes :—

TABLE 7.—*Commercial classification of Bokaro coals.*

Ash content.	Descriptive names.	Commercial classification.
Per cent. 0—5	Bright coals	First and second-class coals : dividing point 15 per cent. ash.
5—22	Silky coals, usually with bright bands	
22—33	Banded silky and shaly coals. Also granular coals.	Third-class coals.
33—50	Dull (silky to greasy-lustred) coals : banded shaly coals.	Fourth-class coals.
50—65	Coaly shales and carbonaceous shales	Coaly and carbonaceous shales.
65—88	M.c. shales (micaceous carbonaceous shales.)	

The dividing point of 15 per cent. of ash between first and second-class coals does not arise from the investigation in this paper, but is based on custom and what is feasible with Bokaro coal. This classification is also suitable for the Korea coals as indicated in column 15 of table 1.

VIII.—COALS AS COLLOID SYSTEMS.

In the preceding sections of this paper the deductions drawn are based upon the actual experimental and observational data accumulated. Incidentally, however, reference is made (page 334) to a former suggestion of mine (1914) that the bright coal (*i.e.*, vitrain) of Korea is a colloidal substance, and this idea is now applied also to the vitrain of Bokaro. Reasons are advanced in support of this suggestion, but they are not sufficient to prove its correctness. Since this paper was sent to the press I have given further consideration to this point and it now appears to me that the statistical data contained in this paper themselves provide strong evidence of the colloidal nature not only of vitrain, but of the vitrain-

durain series. It would cause inconvenience now to attempt to modify the text throughout in conformity with this view, but I propose in this additional section briefly to indicate the manner in which the data given in the body of the paper can be explained in the light of colloidal systems, and in the following additional section (IX) to indicate the light that may be thrown upon practical questions connected with coal if one accepts the view that with some coals at least we are dealing with colloid disperse systems. This separate treatment is all the more appropriate because the data collected in this paper were obtained without any reference to the principles of colloid chemistry.

In the previous sections of this paper it has been shown that the Bokaro coals are made up of four constituents :—

Organic—

(*a*) Vitrain,

(*b*) Vegetable detritus,

Inorganic—

(*c*) Mineral matter in chemical or physical association with organic matter.

(*d*) Mineral matter in mechanical admixture with organic matter.

The intimate manner in which these constituents appear to be associated in coal renders it possible to regard these various associations as disperse systems. Disperse systems are in their simplest form two-phase systems of which one phase is known as the continuous phase (or dispersion medium) and the other as the disperse phase. Each of these phases may be either gaseous, liquid or solid. According to the size of the particles of the disperse phase the system is described as (1) a molecular dispersion (true solution), (2) a colloidal dispersion (emulsoid or suspensoid), (3) a coarse dispersion (emulsion or suspension), the range of size of colloid particles being roughly 0·0000001 cm. to 0·00001 cm. in diameter. Of these the molecular dispersion is an apparently homogeneous system, whilst the other two are heterogeneous systems, the particles of the colloid being ultramicroscopically visible, and those of the coarse dispersion visible under the microscope, or even macroscopically. In emulsoids and emulsions the disperse phase is liquid and in suspensoids and suspensions it is solid.

Of the four constituents of our Bokaro coals as listed above, we can treat (*b*), (*c*), and (*d*) as acting as disperse phases and (*a*) as a dispersion medium.

The aspect of coal that has been specially considered in this paper is the relationship of specific gravity to ash contents, or, in other words, of density to degree of concentration of the disperse phase. In the case of a coarse suspension, which is one form of mechanical mixture, the specific gravity of the system can be calculated from that of the two phases on the assumption of no change of total volume. But, in colloid solutions, owing to the fact that the disperse particles are so small that the ratio of surface to volume is large, so that surface energy comes into play, the specific gravity of the system cannot be so calculated. In fact with both colloid and molecular dispersoids, the density of the disperse system is different, usually higher, than for a mechanical mixture of the two phases, indicating that the association of these two phases has been accompanied by change of volume, usually contraction. In the case of molecular solutions, the density-concentration diagram is a curve concave towards the density co-ordinate. In the case of colloid solutions there is a difference between the type of diagram for emulsoids and suspensoids. Emulsoids give a curve concave towards the density co-ordinate, as with molecular solutions; but with suspensoids the density shows a linear increase with increase of concentration of the disperse phase, so that the curve expressing this relationship is a straight line.[1]

With the preceding introduction we can now mention that briefly speaking the data already given in preceding sections of this paper provide evidence for the following interpretation:—

(1) The coals of the vitrain-durain series of Bokaro and Korea form a series of colloid solutions (suspensoids) in which the vitrain is the dispersion medium and the ash content forms the disperse phase.[2]

[1] See Wolfgang Ostwald, 'A Handbook of Colloid Chemistry', Second English Edition, translated from the German by M. H. Fisher, p. 124, (1919). Later works on colloid chemistry give but little attention to density and concentration diagrams and it is possible that further research may not support Ostwald's criteria *in toto*. Thus some emulsoids and gels may yield convex instead of concave ones. Further, Ostwald's deduction that the density-concentration relationship for suspensoid systems is linear as based on data relative to systems of low degrees of concentration (*e.g.*, 4·4 per cent.). The present investigation relates to a type of system containing up to 40 to 50 per cent. of the disperse phase.

[2] The fragments of vegetable debris form an additional constituent, and as they are at least microscopically visible, they cannot be regarded as forming a part of a colloid system; instead they form a coarse dispersion (suspension) with the same dispersion medium as the colloid particles.

(2) The vitrain itself is a colloid system of the emulsoid or gel type in which it is uncertain whether the moisture or the complex of carbon compounds (or moisture-free vitrain) acts as the dispersion medium.

(3) The carbonaceous shales are mechanical mixtures of inorganic and organic matter.

(4) The shaly coals and coaly shales are the products of interlamination of vitrain and carbonaceous shale.

The deduction that the vitrain-durain series is a series of colloid solutions of the suspensoid type is based on the fact that the relationship between the density and ash contents of coals of this series is a linear one as demonstrated in a previous section. In the work by Wolfgang Ostwald to which reference has already been made it is pointed out (*l.c.*, pp. 134—135) that in suspensoid systems the saturation concentration is usually very low, *e.g.*, 0·1 to 0·2 per cent. for colloid gold. Silver sols containing more than 30 per cent. of silver are mentioned, but it is suggested that this colloid concentration is due either to an admixture of impurities or that one is dealing with a coarse suspension. However, it is theoretically possible, if we assume that the disperse phase in a suspensoid is composed of rigid spherical particles, for the volume of the disperse phase to reach a maximum of about 74 per cent. of the total volume of the disperse system: whereas in both emulsoid and emulsion systems the disperse phase, because the particles thereof can be distorted, can occupy almost the whole of this space, as, *e.g.*, an emulsion of petroleum in soap solution in which as much as 99 per cent. of the former may form the disperse phase (*l.c.*, p. 138).

In our greasy-lustred shale-coal or durain we appear to have a suspensoid system containing from 33 to 39 per cent. of the disperse phase. As, in view of the preceding paragraph, this is a high degree of concentration, it is comforting to be able to point to refined Trinidad asphalt as a colloid system that has been shown to contain 35 per cent. of clay in the colloidal condition dispersed through a medium of bitumen.[1]

[1] Clifford Richardson, 3rd Report on Colloid Chemistry, pp. 98—102, (1920).
The density of the refined asphalt is given as 1·400. As this must be a suspensoid system the density-concentration relationship should be linear. As the disperse phase is probably the same in both the Trinidad asphalt and the Bokaro coals it seems likely that my rule for deducing the specific gravity of ash-free coal should be applicable to the Trinidad asphalt. This would give 1·400—0·354=1·046, or say 1·05 as the density of ash-free Trinidad bitumen.

Let us now consider the vitrain. It has already been pointed out in the footnote to page 327 that the specific gravity of certain coals increases with the moisture contents. If we confine our attention to analyses of vitrain only, we find that the available analyses, ten in number, of vitrain from the Bokaro, South Karanpura, Kurasia (Korea), Talcher and Pench Valley coalfields, and of two specimens from Skye, show the relationship between moisture and specific gravity, when the latter is reduced to an ash-free basis by application of my linear rule, that is expressed by the following figures :—

TABLE 8.—*Moisture and specific gravity of Indian vitrains.*

Locality.	Moisture.	Specific gravity of ash-free vitrain.	
	Per cent.		
Bokaro	1·21	1·252	Caking.
Do.	1·99	1·260	
Barkui (Pench Valley)	2·20	1·276	
Bokaro	2·24	1·264	
Argada (South Karanpura)	6·27	1·289	
Korea	9·80	1·295	Non-caking.
Skye	11·41	1·303	
Do.	11·72	1·318	
Korea	13·02	1·303	
Talcher	15·08	1·323	

When the analyses are arranged in order of moisture contents, as in the foregoing table the regularity of the figures of specific gravity is seen to be spoilt by two analyses, namely the 3rd and the 8th, which show specific gravities somewhat too high for their position in the series. Neglecting these, the remaining eight analyses, when plotted as a density-moisture diagram, yield a well-marked curve.[1] This proves that we are not dealing with a suspensoid

[1] This is not given now, because specimens of vitrain from various additional Indian localities are being obtained in order to provide additional data. It appears to me, however, to be very remarkable that specimens collected from six different coalfields, two different countries, and two different geological periods (Carboniferous and Tertiary), should yield such a result.

system. That we are not dealing with a series of coarse suspensions or mechanical mixtures is proved by the fact that higher moisture or water is accompanied by higher density, instead of by a lower one, as would be the case for a mechanical mixture. This leaves us the choice of a molecular solution and a colloid system (an emulsoid or a gel). The fact that the moisture forms only from 1 to 13 per cent. by weight of the total seems to preclude us from regarding these vitrain specimens as molecular solutions, so that we seem compelled to accept vitrain as a colloid system. Whether in this system the moisture acts as the dispersion medium and the complex of carbon compounds (let us call this complex *moisture-free vitrain*) as the disperse phase or *vice versa*, we have no evidence, nor do we know whether the system should be regarded as an emulsoid or a gel, though the latter seems more likely.

Summarising it appears then that vitrain may be regarded as a colloid system, of emulsoid or gel type, of moisture and moisture-free vitrain[1]; and durain as a colloid system in which the vitrain acts as a dispersion medium containing two disperse phases, namely ash (suspensoid) and vegetable detritus (coarse suspension).

IX.—PRACTICAL APPLICATIONS.

The relationship described in this paper between the specific gravity and ash contents of coal and the specific gravities and moisture contents of specimens of vitrain has been explained in a previous section on the basis of the properties of disperse systems, both mechanical and colloidal. The relationship is pointed out and the conclusions concerning the colloidal nature of some coals that follow therefrom enable one to offer definite suggestions on various practical problems connected with coal. Some of these suggestions amount really only to suggestions for further research by those who have the opportunity for such work. But it will probably be useful if I enumerate here such points as have occurred to me.

Suggestions can be offered under the following headings :—

(1) Prospecting for coal.

(2) Coal washing and flotation.

[1] This is the simplest treatment for vitrain. The 'volatile matter' and 'fixed carbon' also vary progressively with the specific gravity of vitrain and ultimately a less simple treatment may be necessitated by the data.

(3) Coking.
(4) Manufacture of liquid fuel from coal.

Prospecting for coal.

The linear relationship between specific gravity and ash contents that applies to the vitrain-durain series of coals enables any prospector who knows the fundamental specific gravity of ash-free coal of that series to determine in the jungle the ash contents of a lump of coal by the very simple expedient of taking the specific gravity with a Walker's balance. As he can in this way make a rapid ash analysis of as many varieties of coal as he likes, it is easy for him to form in the jungle a rough estimate of the quality of coal seams encountered and to determine then and there whether the expenditure and time necessary for careful sampling is justifiable (see page 326). Although this method is strictly applicable only to coals belonging to the vitrain-durain series it can also be used for mechanical mixtures represented by shaly coals without serious error (see page 334).

Coal washing and flotation.

Any attempt to beneficiate or improve the quality of coal by methods of washing and flotation depends obviously upon the state of association between the organic and inorganic constituents of the coal. It will be accepted as obvious that neither of these methods can have any hope of success when applied to colloidal systems, that is to say, to the vitrain-durain series, except in so far as a particular coal has a portion of its vitrain segregated into definite bands. In the case of the mechanical mixtures represented by interbanded vitrain and carbonaceous shale on the other hand, the difference between the specific gravity and other properties of the vitrain and of the carbonaceous shale is so high that, given a sufficiently high proportion of vitrain, the beneficiation of the coal by methods of flotation or washing, may conceivably be an economically feasible proposition.

Coking.

The factors in the composition and constitution of a specimen of coal that may confer upon it the property of yielding coke when heated under suitable conditions do not appear to be fully understood. This investigation seems to throw light upon one factor that may be of material importance. It has been thought that the presence of vitrain is helpful to the coking properties of a coal and the presence of durain is

inimical thereto. This investigation shows, however, that the problem is not so simple. A reference to the figures given on page 349 will show that if one can judge coking properties of a coal from the ordinary laboratory determinations of caking properties, then with vitrain the ability to coke is in part a function of moisture, for those coals with the lower moisture show caking properties and those with higher moisture show non-caking properties.[1] The analyses of dull greasy-lustred coal (durain) given on page 340 from Korea and Bokaro tell the same story. The Bokaro durain with 39 per cent. of ash and 1 per cent. of moisture cakes strongly. The two specimens of durain from Korea with 33 to 35 per cent. of ash and about 4 per cent. of moisture do not cake. On comparing the data for vitrain with the data for durain we see that even 39 per cent. of ash contents does not harm the ability of the coal to cake; but that with both vitrain and durain high moisture is accompanied by absence of caking properties.[2] It does not follow that these observations will prove to be applicable to all coals, for it will be noted that all the coals now under consideration with the exception of the two specimens from Skye are of Palaezoic age.

On the practical side one might think that, on the basis of these observations, it should be easy to convert a non-coking coal into a coking coal merely by the operation of reducing the moisture contents. The problem is probably not as simple as this, for in the ordinary process of determining the 'moisture' contents of coal the moisture is driven off without converting the coal into a caking coal. This moisture, moreover, is not loosely held hygroscopic moisture, but is obviously much more intimately associated, if my interpretation is correct that it forms a separate phase in the vitrain colloid system. The results obtained from practical tests on a large scale do not, however, always agree with those obtained in the laboratory, so that large-scale experiments upon the removal of moisture from a non-coking coal otherwise similar in analysis to low-moisture coking coals would seem to be worth while. The ordinary processes of making coke result in the rapid application

[1] Moisture is, of course, not the only factor that counts. The same data show also a regular change of volatile matter and fixed carbon with moisture and specific gravity. Further data are being collected and it is hoped to discuss vitrain analyses in a later paper.

[2] Since this paper was sent to the press, Mr. Balaram Sen of the Tata Iron and Steel Co., Ltd., has described before the Indian Science Congress at the Calcutta meeting, January 1928, the results of a large series of practical tests directed to ascertain the factors that confer coking properties upon coal. He finds that high ash does not prevent a coal from coking, but that high moisture does, his results proving thus to be in accord with mine.

of heat to the material being under treatment with the result, no doubt, that the carbon compounds are affected by the heat before any considerable reduction in the moisture contents has been effected. It may, therefore, be offered as a suggestion worth practical test that it may conceivably be possible to convert a suitable non-coking coal into a coking coal by holding it for a considerable time at a temperature sufficient to remove the 'moisture' contents before raising the temperature of the coke-oven to heights that will effect a breaking up or distillation of the carbon compounds.

Manufacture from coal of liquid fuel.

If one accepts the view that certain coals may be regarded as colloid systems, it seems possible to outline theoretically the broad steps necessary to convert such coal into liquid fuel. The apparently solid condition of the coal may be regarded as due to the high viscosity of the vitrain. The first step, therefore, would be one that reduces this viscosity to such an extent that the carbon compounds possess the properties of a mobile fluid. The modern method of hydrogenisation, which is directed towards lowering in their respective series the hydrocarbon compounds contained in coal, is obviously a method of effecting this result. Should the coal thus treated be an impure one with a large amount of mineral matter in colloid solution then the process of treatment would presumably result in the production of a liquid fuel still containing such particles in the colloidal condition. Two methods appear to suggest themselves of purifying the liquid fuel from these colloid particles. One is obviously the method of distillation, which results in the ash contents being left behind. The other would be the addition to the fuel of some electrolyte—should this be practically feasible—for the purpose of causing the coagulation and precipitation of the colloid mineral particles.

X.—SUMMARY.

1. In studying a mineral deposit it is desirable not only to take average samples, but also to choose carefully hand-specimens representing the various mineral types present and then to subject these specimens to the test of assay or chemical analysis conducted on pieces of which the specific gravity has been determined.

2. Such work on specimens derived from the coal seams of Korea State, C. P., in 1913 led to the discovery of a definite empirical

relationship between the ash contents and density of a coal. Taking the specific gravity or density of pure ash-free Korea coal (bright coal) as 1·29 (k), the ash contents (a) of other Korea coals of density g was found to be very closely, with one exception, governed by the empirical straight-line rule

$$a = 100\ (g - k).$$

3. Such a rule, if of general application, would obviously be of the first importance to the prospector, as by determining the specific gravity of representative specimens of coal with a Walker's balance in the field he could determine roughly the ash contents of each type and therefore of any seam, and thus decide in the field whether a seam was worth proper sampling for analysis.

4. In the course of an investigation of the Bokaro coalfield during 1916 and 1917 the rule discovered in Korea was tested further by the selection and analysis of a much larger series of picked specimens, carbonaceous shales as well as coals being taken into the investigation.

5. The results given in table 2 show that in most cases this empirical rule applies to coals containing up to 50 per cent. of ash, the fundamental specific gravity constant (k) being in this case 1·26 instead of 1·28, the constant finally adopted for Korea. All the specimens from both fields come from the Barakar series.

6. The results are plotted in Plate 26, from which it is seen that in carbonaceous shales (that is those carbonaceous substances with over 50 per cent. of ash) the empirical rule no longer applies, the specific gravity of the carbonaceous shale being increasingly in excess of that indicated by the rule (which corresponds to a straight line as indicated in the diagram).

7. Discussing for the present only coals (carbonaceous substances with not greater than 50 per cent. of ash), we find that in certain cases the coals have a specific gravity seriously above or below those indicated by the empirical rule. These deviations are indicated by plus and minus signs (tables I, 2, and 4).

8. The plus and minus coals are represented in the diagram in Plate 26 by spots respectively above and below the curve.

9. The plus coals are found in the one case studied to owe their high density to ash abnormally rich in oxide of iron, and therefore presumably of abnormally high density (see page 325).

10. The zero or normal coals, which are those agreeing with the empirical curve (a straight line), have, nevertheless, a higher

density than figures obtained by calculation of the specific gravity of mechanical mixtures of pure coal and pure shale. This fact is taken as indicating some form of chemical or physical combination with decrease of volume between the organic and inorganic matter in coals with ash contents up to 45 per cent. of ash (see p. 333 and Plate 27).

11. The minus coals are ones with a density less than that required by the empirical rule. In one case the low figure (—13) was not confirmed on repetition of the work. But the figure of —7 for one Korea coal has been confirmed, and this coal, with two Bokaro coals showing deviations of —2 and —5, may be examples of coals in which this intimate association between organic and inorganic matter does not exist, so that the specific gravity conforms to that indicated by calculation for mechanical admixture. (See table 4).

12. With ash in excess of 50 per cent. (carbonaceous shales) the empirical straight-line rule is no longer followed, and instead it is found that the density-ash curve is closely that for mechanical mixtures of coal of density 1·26 and shale of density 3·00 (See table 4).

13. This curve crosses the straight line representing our empirical rule at 45 per cent. of ash. With ash below 45 per cent. only minus coals follow the calculated curve, most coals then following the straight-line law (zero or normal coals); consequently the space between the two curves indicates condensation of volume due presumably to some form of chemical or physical association of the coal with its ash contents.

14. Our carbonaceous substances are thus roughly divisible into (1) coals with not greater than 50 per cent. of ash and in which the ash, if not greater than 45 per cent., is at least partly in chemical or physical association with the carbonaceous contents, and (2) carbonaceous shales with greater th n 50 per cent. of ash in which the organic and inorganic matter behave as if in mechanical admixture.

15. The macroscopically homogeneous substances making up the majority of the Bokaro and Korea coals are three in number (see p. 341), namely the fundamental colloidal substance or bright coal (vitrain), greasy-lustred dull coal (durain), and m.c. shale (micaceous carbonaceous shale). 'Mother-of-coal' (fusain) is seen sometimes in films. The dull greasy-lustred coal carries 33 to 39 per cent. of ash and has a density of 1·61 to 1·65. It may be expected to carry

a portion of its mineral matter in a state of chemical or physical association with the organic matter.

16. An analysis of the data, taking account of both the actual macroscopically visible characteristics of the coals and of their specific gravity deviations, shows that our Bokaro specimens can be arranged into two series:—

——	Ash contents.	Specific gravity.	Deviations.
	Per cent.		
I. Vitrain-durain series (Bright, silky, and dull coals).	2·31 to 39·11	1·28—1·65	0
II. Vitrain-carbonaceous shale series. (Shaly coals, coaly and carbonaceous shales).	27·61 to 89·41	1·49—2·58	—5 to +45

17. The Korea specimens all belong to the vitrain-durain series with ash contents ranging from 0·51 to 34·96 and specific gravity from 1·30 to 1·61.

18. A consideration of the data given in table 2 and Plate 26 leads one to suggest that the most useful commercial classification of the Bokaro coals would be as follows:—

Ash contents.	Descriptive names.	Commercial classification.
Per cent.		
0—5 .	*Bright coals*	First and second-class coals: dividing point 15 per cent. of ash.
5—22 .	*Silky coals* usually with bright bands .	
22—33 .	*Banded* silky and shaly *coals*. Also granular coal.	Third-class coals.
33—50 .	*Dull* (silky to greasy-lustred) *coals*: shaly coals.	Fourth-class coals.
50—65 .	*Coaly shales* and carbonaceous shales .	Coaly and carbonaceous shales.
65—88 .	*M.c. shales* (micaceous carbonaceous shales)	

This classification also applies to the Korea coals.

19. If one treats these coals as disperse systems, consideration of the density-ash relationships discussed in sections III and IV shows that the vitrain-durain series can be treated as a series of suspensoid colloid systems in which the vitrain acts as the dispersion

medium, and the ash contents as the disperse phase (suspensoid) with the vegetable detritus contained in the durain as a second disperse phase (coarse suspension).

20. Similarly, consideration of the fact that in a series of analyses of vitrain from various localities the specific gravity increases with the moisture enables one to deduce that vitrain itself is an colloid system (emulsoid or gel) in which the moisture-free vitrain and the moisture may be regarded as separate phases.

21. On the basis of the data collected in this paper and the interpretation of coals as colloids, it is possible to offer suggestions on certain practical aspects :—

1. Prospecting.
2. Coal-washing and flotation.
3. Coking.
4. Production of liquid fuel from coal.

Reference to prospecting is made in paragraph 3 above. We need refer here only to coking, by mentioning that the vitrains and durains lower in moisture are caking and those higher in moisture are non-caking.

LIST OF PLATES.

PLATE 26.—Diagram showing specific gravity and ash contents of coals and shales from Korea and Bokaro.

PLATE 27.—Diagram showing density-ash curves for both chemical or physical associations (colloid systems) and mechanical mixtures of coal and shale from Bokaro.

NOTE ON A CONTACT OF BASALT WITH A COAL-SEAM IN THE ISLE OF SKYE, SCOTLAND: COMPARISON WITH INDIAN EXAMPLES. BY L. LEIGH FERMOR, O.B.E., D.SC., A.R.S.M., F.G.S., *Officiating Director, Geological Survey of India.*

IN the summer of 1914 I enjoyed the privilege and good fortune of spending several weeks in Skye in the company of Dr. A. Harker. Amongst many interesting sections visited one was of special interest.

In the cliff a little south of Dúnan Earr an Sgúirr, between Loch Brittle and Loch Eynort, the little ravine of Allt Geodh' a' Ghamhna shows a section of some 30 feet of conglomerates and tuffs with coal seams, intercalated in the succession of Tertiary basaltic lava flows of Skye, and analogous in position to the Intertrappean beds of the Deccan Trap lavas of India. Details of this section are given on page 26 of Harker's *Tertiary Igneous Rocks of Skye,* and may be abstracted as follows:—

Basaltic lavas, with sills, above.

Coal-seam	0—3 in.
Tuff	1 ft.
Coal-seam	0—3 in.
Conglomerate	6—7 ft.
Tuff with impure coal-seam (6 to 8 inches) in lower part	5—7 ft.
Conglomerate	5—6 ft.
Tuff	$2\frac{1}{2}$—3 ft.
Conglomerate	about 9 ft.

Basaltic lavas, with sills, below.

The conglomerates all possess a tuff matrix.

My interest was aroused by the fact that although the lava was resting directly on the uppermost seam of coal there was no visible difference between this coal and that of the lower seams, except in a very thin surface layer, not more than 0·5 mm. thick, of the uppermost seam.

Owing to denudation the details of the section have, of course, changed somewhat since Dr. Harker's previous visit some years before. Confining myself to the upper parts of the section I found

that at the point examined the lower of the two upper seams noted above was about ½ inch thick and rested directly on the conglomerate, following the curves of the pebbles. It was overlain by 3 to 4 inches of sandy tuff containing carbonised plant remains followed by two more thin coal seams, each ⅛ to ½ inch thick and separated by 1 to 2 inches of tuff tending to be shaly: these two seams and the tuff together correspond to the uppermost coal-seam of Dr. Harker's section. The upper of these two coal seams was overlain by vesicular and amygdaloidal earthy basalt resting on it in immediate contact. I collected specimens of these two upper coal seams and these have been analysed in the laboratory of the Geological Survey of India by Mahadeo Ram, with the results shown in columns A and B below. It will be seen at once that the upper coal seam (28/826) is practically identical in composition with the coal seam (28/827) 2 inches below, from which it seems evident that the lava has produced no appreciable effect on the upper coal and therefore cannot have been very hot by the time it came in actual contact with the coal or the vegetable matter from which the coal has been formed.

——	A Lower coal seam (28/827) Picked material.	B Uppermost coal seam (28/826) Picked material.	C Crust from 28/826.	D Residue per 100 grams of coal assuming ash constant in changing from B to C.	E Percentage loss.
Moisture . . .	11·41	11·72	16·71	7·03	40·02
Volatile matter . .	30·85	31·25	45·20	19·03	39·10
Fixed carbon . .	53·53	52·98	28·47	11·99	77·37
Ash	4·21	4·05	9·62	4·05	..
Coking properties . .	Does not cake	Does not cake	Does not cake	..	..
Colour of ash . .	Light brown	Brown	Light grey	..	..
Specific gravity . .	1·345	1·350	..	..	..

Each of these coals is a jointed pitchy-lustred coal of lignitic aspect with conchoidal fracture; but the actual surface of the upper seam (28/826) has a somewhat 'sintered' aspect, which is seen through a lens to be due to minute polygonal jointing at right angles to the surface of the coal: this layer is about 0·5 mm. thick. Some of this altered coal was scraped off and analysed, with the

result shown in column C of the table. It was impossible to be certain that the material so obtained was free from portions of the underlying unaltered coal; consequently this analysis must be taken as an expression of the change produced by the lava at its contact with the coal rather than as a full measure of the change. It shows apparently a marked increase in ash, volatile matter, and moisture, and a decrease in fixed carbon. But if we assume that the quantity of ash in the coal undergoing modification has remained a constant, then it is evident that 2·38 parts of coal have yielded 1 part of altered coal, with the percentage losses shown in column E, from which it is interesting to note that the percentage loss of fixed carbon has been nearly twice as great as that of volatile matter and moisture.

It is interesting to contrast this case with the contact metamorphic effects produced by basic dykes intruded into coal seams. In the case of the mica-apatite-peridotite dykes of the Giridih coalfield, India,[1] a 4-ft. dyke has produced a coked zone in the coal 3½ ft. wide, with a resultant great increase in the proportion of fixed carbon to volatile matter. Similarly a 'white trap' dyke (originally basalt) 1 to 4 feet thick, intruded into a coal seam in the Barkui colliery, Pench Valley coalfield, India,[2] has altered the coal to a distance of 12 inches from the contact. As the Pench Valley coal is a non-coking coal according to Dr. Fox,[3] the amount of coking effected at the contact was very small, but the altered coal showed a considerable increase in the fixed carbon relative to volatile matter.

It is thus seen that the effect of the lava of Skye on the ratio of fixed carbon to volatile matter is the reverse of that of the basic dykes on seams of completely-formed coal. No obvious explanation of this difference offers itself.

But it seems possible to explain why the Skye lava has made its presence felt only for a fraction of a millimetre, whilst the dykes referred to above have altered the coal to a distance of 1 to 4 feet from the contact. In the latter case the molten lava occupying the fissure must have been very hot, have come into immediate contact with dry or relatively dry material, and have cooled more slowly than a surface lava. On the other hand it is evident that

[1] T. H. Holland & W. Saise, *Rec. Geol. Surv. Ind.*, XXVIII, pp. 132—5, (1895).
[2] C. S. Fox, *Rec. G. S. I.*, XLIV, pp. 123—136, (1914).
[3] **But see *Mem. G. S. I.*, XLI, p. 185.**

the lava of Skye must have been relatively cool by the time it came in contact with the vegetable matter that is now coal. But the ordinary temperature of basaltic lava in the molten condition may be taken as approximately 1000°C.[1]: consequently it is of interest to enquire how the vegetable matter that is now coal escaped alteration except in its topmost film. The answer is seen in the physical character of the lava. It is now an earthy vesicular rock with the vesicles occupied by calcite and a chloritic substance. Vesicular structure at the base of a lava flow may be explained in two ways. The surface of a flow cooling in contact with the air assumes a vesicular character due to the expansion of dissolved or entangled gases under atmospheric pressure. During the flow of the lava portions of the vesicular surface may be rolled underneath the flow at the advancing front. This, however, could not happen in the case of a very fluid, rapidly flowing lava, so that the base of a basaltic lava flow should sometimes be non-vesicular, as, judging from the Indian Deccan Trap flows, seems often to be the case. If, however, the lava should flow into a shallow body of water, such as a fresh-water pool or lagoon, it must to a large extent displace the water. Any water that becomes imprisoned below the flow must be vaporised and penetrate into the base of the lava and render it vesicular. This water must also act in another way: in the form of steam it must act as a cushion and prevent the hot lava from coming at once into contact with the bottom of the pool, so that a layer of vegetable matter lying there would be protected from the lava by vapour until the lava had become too cool to have much effect on this vegetable matter. There would also be a great abstraction of heat from the lava in the process of heating and vaporising the water, and this would cause a more rapid freezing of the base of the flow than if the lava were flowing over dry land.

The foregoing seems to explain in a reasonable manner why only the actual upper surface of the vegetable matter in our Skye case was affected by the lava. The constitution of the vegetable matter before the advent of the overlying lava is difficult to deduce, but if the change in the surface of the upper seam is really a form of coking it looks as if this vegetable matter must already have been somewhat compacted and on the way to coal before the lava was erupted.

[1] Harker: 'Natural History of Igneous Rocks', pp. 185—6.

Similar cases of actual contact of a lava flow with coaly matter have been described by Sir A. Geikie[1] from both Skye and Canna in the Western Isles of Scotland, and in only one case is it noted that the lava has had a contact effect on the vegetable matter. This is at Cul nam Marbh, Canna, where a coniferous tree stump, apparently growing *in situ*, has been charred (*l.c.*, p. 362); it is conceivable that this stump was projecting above the water in which the associated vegetable matter was deposited, so that it came in immediate contact with the hot lava.

[1] *Q. J. G. S.*, LII, pp. 341, 359, and 362, (1896).

THE BARAKAR-IRONSTONE BOUNDARY NEAR BEGUNIA, RANIGANJ COAL-FIELD. BY CYRIL S. FOX, D.SC., M.I.MIN. E., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With Plates 28 and 29.)

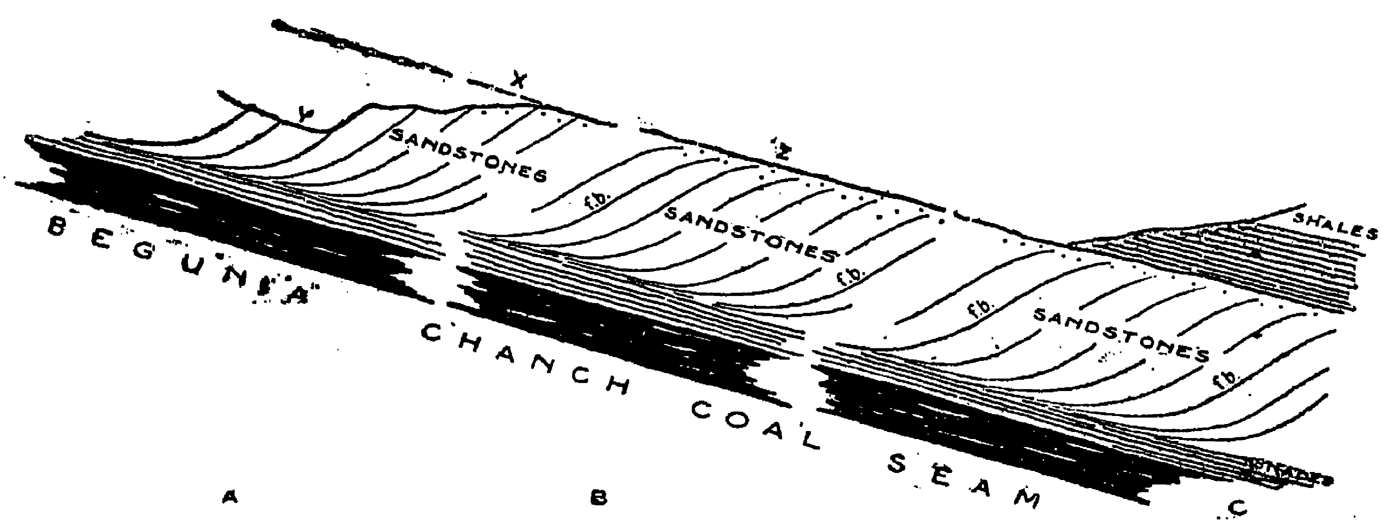
THE re-survey of the Raniganj coal-field now in progress has shown that the junction between the Barakars and the overlying Ironstone Shales is normally a conformable one. It is at a higher geological horizon than is suggested by its position, north of the Grand Trunk road at Begunia, on Blanford's map. This junction really follows a line in a W.S.W. direction from north of Kulti and south of Begunia to the Barakar river. It is a faulted boundary. The shales shown in the sketch of the Jain temple section by W. T. Blanford[1] are carbonaceous, but they do not contain ironstone, and for this reason should be included in the Barakars. Furthermore these shales are overlain by the pebbly sandstone, of a Barakar facies, which forms the ridge on which Begunia is situated. It has, however, been difficult to explain the apparent remarkable unconformity to which Blanford drew attention.

While working on about the same geological horizon, *i.e.*, above the Chanch seam, which is the westward continuation of the Begunia seam, in the Khudia *nala* near Chanch, I discovered an exposure showing the finest example of false- or current-bedded sandstone that I have seen. The real dips of this sandstone are to the south-east while the planes of current bedding dip northward. (Plate 29). It immediately occurred to me that, as this sandstone was almost certainly the same as that on which the Jain temples at Begunia stand, the northerly dips, which are so evident in the sandstones between Begunia and Barakar, might really be the dip of planes due to current bedding. (Plate 28, fig. 2.) On careful examination, particularly of a small quarry, which was not open in Blanford's day, just north of the Grand Trunk road and east of the road to Barakar station, I found that the planes of apparent bedding do not continue to the surface of the sandstone. This they should do if the surface of the sandstone was a weathered and eroded unconformity. The low southerly dip is the true dip of

[2] *Mem. Geol. Surv. Ind.,* III Art. 1, (1865), p. 42.

these sandstones. It agrees with the dip slope of the sandstones at the Jain temple exposure, as well as with the southerly dip seen in the Chanch (Khudia) section. The northerly dips in the quarry are undoubtedly those of the planes of false-bedding. This will be seen from a scrutiny of Plate 28, fig. 2. In short there is no 'roll' of the beds, and certainly no unconformity. The exposures in that area convey a wrong impression to the mind if the meaning of the details in the quarry section is not grasped. Without the quarry section, which was not open in Blanford's time, it would be quite impossible to arrive at any other conclusion than that of Blanford. A true explanation of the observed facts is shown in the accompanying sketch section.

FIGURE 1.



A.	B.	C.
EXPOSURES SOUTH OF BARAKAR.	SECTION IN QUARRY.	SECTION AT JAIN TEMPLES, BEGUNIA.
It is wrong to assume an anticlinal at X. This would make the beds at Y above those in the Jain temple section.	The false bedding planes, *fb*, although sharp, do not run out to the true dip slope at Z.	Here dip slopes have so far only been seen. The false bedding has not been recognised in the dirty pool below the temple.

LIST OF PLATES.

PLATE 28. FIG. 2.—Barakar sandstones in a quarry, Begunia, near Barakar railway station.

PLATE 29.—False-bedded Barakar sandstone at Chanch, Raniganj coalfield.

THE RANIGANJ-PANCHET BOUNDARY NEAR ASANSOL, RANIGANJ COAL-FIELD. BY CYRIL S. FOX, D.SC., M.I.MIN.E., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With Plates 28 and 30.)

IN his survey of the Raniganj coalfield W. T. Blanford (*Mem. Geol. Surv. Ind.*, III, pp. 126—131) gives a short clear description of the Panchets and states (p. 127) that there is a slight unconformity between the Panchet and the underlying Raniganj stage. He does not, however, mention the fossil-wood horizon in which the fossil tree was found near Asansol. The re-survey of the Raniganj coalfield has now proceeded far enough for a definite opinion to be given with regard to the exact boundary between the Raniganj stage and the overlying Panchet beds.

Mr. Sethu Rama Rau, Assistant Superintendent, Geological Survey of India, working south of the Damuda river, has found a well-marked fossil-wood sandstone almost at the top of the Raniganj stage. Mr. A. K. Banerji, Assistant Superintendent, Geological Survey of India, working from the Damuda river north-eastwards by Patmohna and Hirapur to the Kumarpur railway cutting on the East Indian Railway two miles west of Asansol, has traced the same fossil-wood horizon to this place, and finds that this horizon must be included in the Raniganj stage and not in the Panchet stage. I have seen the chief sections on which Mr. Banerji bases his opinions and agree with him that there is a slight but local unconformity (Plate 28, fig. 1) between the undoubted Panchet beds and the underlying strata in which the fossil-wood sandstone occurs. This fossil-wood sandstone is of considerable value as a stratigraphical horizon, as it can be followed across the whole of the western part of the Raniganj coalfield.

The fossil tree erected in the Indian Museum comes from the fossil-wood sandstone exposed in the Kumarpur railway cutting west of Asansol. This tree, according to Professor B. Sahni, belongs to 'the Cordaitales, one of the most important groups of Palaeozoic Gymnosperms.' Details of the discovery are given in the *Records, Geological Survey of India*, LVIII, pt. 1, 1925, pp. 75-79. In this account it was stated that the sandstone in which the silicified tree trunks were found belongs to the Panchet beds. The reasons

for this opinion are not stated. I found another silicified tree trunk in the same cutting in October 1925 (Plate 30, fig. 2). This was extracted and brought to Calcutta, but has not yet been mounted. It was nearly 50 feet long as it lay when fully exposed. Professor Sahni, considered that the first tree belonged to the genus *Dadoxylon* and showed well-marked growth rings (Plate 30, fig. 1). He gave no name for the species. He, however, drew attention to the fact that it was very similar to two species—namely *D. indicum*, Holden, from Deogarh, and *D. bengalense*, Holden—from Brahmanbarari in the Jharia coalfield. Both these species were from the Barakar stage of the Damuda series (Lower Gondwanas). Seeing that the palaeontological evidence supports a Palaeozoic rather than a Mesozoic age I feel that an uppermost Raniganj age rather than a lowest Panchet age must be accepted for the fossil-wood sandstone and suggest that its official designation might be the Kumarpur (fossil-wood) sandstone.

This is the only fossil-wood (silicified) horizon known in the Lower Gondwanas, and should it be also found to occur in the eastern part of the Raniganj coal-field, will be of great use as a stratigraphical horizon.

LIST OF PLATES.

PLATE 28, FIG 1.—Panchet-Raniganj unconformity in stream near Junut village, Raniganj coalfield.

PLATE 30.—FIG. 1.—Fossil tree from Kumarpur railway cutting showing rings of growth.

FIG. 2.—Fossil tree in Kumarpur railway cutting.

A PERMO-CARBONIFEROUS MARINE FAUNA FROM THE UMARIA COAL-FIELD. BY F. R. COWPER REED, M.A., SC. D., F.G.S. (With Plates 31 to 36.)

INTRODUCTORY REMARKS.

THE fossils described in this paper were collected from beds associated with those of undoubted Lower Gondwana age at Narsarha railway cutting, Umaria, Rewah State, Central India, in 1922, but the presence of marine fossils at this locality had been observed in the previous year. A brief note on their occurrence was published in the General Report of the Geological Survey for 1921 [1], but no precise determination of the specimens was given. In this report it was observed that the most abundant fossil was a species of *Productus* which Mr. Tipper considered to be new to India; and this shell forms practically the whole of the shell-band, 3 inches thick, which contains most of the fossils. Another brachiopod attributed to *Spiriferina* was also mentioned, and it was regarded as "close to and probably identical with *Sp. cristata* var. *octoplicata*." The shell-band is described as resting on quartz-grits which pass up conformably through it into sandstones of Lower Barakar age.

The description of these fossils, which were sent to me for identification in 1925, had been finished and the plates to illustrate them had been drawn when further material collected by Mr. E. R. Gee in 1926, was submitted to me, necessitating a revision of my previous work and throwing further light on the stratigraphical age of the beds. These new fossils were found in the same locality on both sides of the Narsarha railway cutting two miles west of Umaria railway station in four distinct bands, the lowest one D, (K 23·264) containing large numbers of small gasteropods in a gritty clay; the next one, C, (K 23·263) lying $2\frac{1}{2}$ feet higher and containing chiefly brachiopods, in red and olive-green clays associated with the *Productus* shell-band and about 8-9 inches below the succeeding horizon, B, (K 23·262) which is a yellow brown sandy clay $1\frac{1}{2}$ inches thick. The highest horizon, A, (K 23·261) is an 8-inch band in the soft fine yellow sandstone of the basal Barakar series, and contains many specimens of *Productus*, *Pleurotomaria*, etc.

[1] Fermor, *Rec. Geol. Surv. Ind.*, Vol. LIV, pt. 1, August 1922, pp. 14-16; *Nature*, Vol. CX, 1922, p. 556; Wadia, 'Geology of India', 2nd edit., 1926, London, p. 148.

The great interest and importance of marine fossils occurring in the Gondwanas of Central India were recognised in 1921, and the determination of their affinities as a guide to the stratigraphical horizon of the beds has therefore demanded particularly detailed study.

The material at first submitted to me in 1925 consisted of masses and slabs of the shell-band mainly composed of more or less imperfect specimens of *Productus* densely aggregated; there were also a few loose specimens weathered out free from the matrix. Some of the slabs were in a rotten crumbling condition, the matrix being of a soft friable argillaceous nature and falling to pieces on exposure, so that the extraction of more than fragments of fossils was difficult. But it was from material of this character that the first specimens of the small *Pleurotomaria*, *Rhombopora* and ostracods were picked out.

The harder masses of rock forming the shell-band do not consist of anything but agglomerated shells of *Productus*, mostly of one species, with here and there a crushed specimen of the small *Pleurotomaria*. On the softer pieces of rock other fossils also occur, and frequently they have their minute surface-ornamentation beautifully preserved. The specimens in this first collection, however, were in nearly every case fragmentary and very imperfect, so that it was difficult to arrive at any satisfactory conclusions. The new material collected subsequently by Mr. Gee is fortunately in a much better condition, and several new species not previously observed have been detected, while it has been possible to define the characters and ascertain the affinities of the others more precisely. A certain number of shells belonging to species of *Productus*, *Spirifer*, *Reticularia* and *Pleurotomaria* occur loose and almost free from matrix, and some are in a good state of preservation. As above noticed, they occur in several distinct bands of rock which contain slightly different assemblages of fossils, but most of them are common to all the horizons and no important difference in age can be established.

DISTRIBUTION OF THE SPECIES.

(*First Collection*).

K 21·424	*Productus umariensis* sp. nov.
	,, ,, var. *spinifera*.
	,, *rewahensis* sp. nov.
	,, ,, var. *coroides*.

	Spirifer narsarhensis sp. nov.
	,, ,, var. *pauciplicata.*
	Reticularia barakarensis sp. nov.
	Orthotichia ?? sp.
K 21·425 . . .	*Rhombopora* sp.
	Productus umariensis sp. nov.
	Spirifer narsarhensis sp. nov.
	Athyris aff. *protea* Abich.
	Pleurotomaria umariensis sp. nov.
	Cytherella ? sp.
	Palaeocypris sp.
	Jonesina ? sp.
K 21·426 . . .	*Productus umariensis* sp. nov.
K 22·972 . . .	*Pleurotomaria umariensis* sp. nov.
K 22·973 . . .	*Pleurotomaria umariensis* sp. nov.
	Dermal tubercles of fish.
(*Second Collection.*)	
Horizon A (K 23·261)	*Productus rewahensis* var. *coroides.*
	Spirifer narsarhensis.
Horizon B (K 23·262)	*Spirifer narsarhensis.*
	,, ,, var. *pauciplicata.*
	Reticularia barakarensis.
	,, ,, var. *subplicata.*
	Crinoid stem and joints.
	Dermal tubercles of fish.
Horizon C (K 23·263)	*Productus rewahensis.*
	,, *umariensis.*
Horizon D (K 23·264)	*Productus rewahensis.*
[=K 22·972, 933]	*Janeia* aff. *biarmica* (De Vern.)
	Pleurotomaria umariensis.
	Crinoid stems.
	Dermal tubercles of fish.

(K 23·265) (From east side of railway cutting.)
Productus umariensis.
Spirifer narsarhensis.

COMPLETE LIST OF FOSSILS.

Crinoidal stems and joints (K 23·262) (K 23·264).
Rhombopora sp. (K 21·425).
Productus umariensis sp. nov. (K 21·424), (K 21·425) (K 21·426).
,, ,, var. *spinifera* (K 21·424).
,, *rewahensis* sp. nov. (K 21·424) (K 23·263) (K 23·264).
,, ,, var. *coroides* (K 21·424) (K 23·261).
Spirifer narsarhensis sp. nov. (K 21·424) (K 21·425) (K 23·262).
,, ,, var. *pauciplicata* (K 21·424) (K 23·262).
Reticularia barakarensis sp. nov. (K 21·424) (K 21·425) (K 23·262).
,, ,, var. *subplicata* (K 23·262).
Athyris aff. *protea* Abich (K 21·425).
Orthotichia ? sp. (K 21·424).
Janeia aff. *biarmica* (De Vern.) (K 23·264).
Pleurotomaria umariensis sp. nov. (K 21·425) (K 22·972).
(K 22·973) (K 23·264).
Jonesina ? sp. (K 21·425).
Cytherella ? sp. (K 21·425).
Palaeocypris sp. (K 21·425).
Dermal tubercles of fish (K 22·973) (K 23·262) (K 23·264).

DESCRIPTION OF THE FOSSILS.

Crinoidal stem and joints.

Pl. 36, figs. 15, 15a.

There is one portion of the stem of a crinoid (K 23·262) of a regular cylindrical shape measuring 6·5 mm. in length and 4 mm. in diameter and consisting of six joints of rather unequal thickness. The periphery of each joint is gently convex and smooth; the articulating face has an outer marginal ring of about 32 short coarse radial ridges extending inwards for about one-fifth to one-fourth of the diameter; the rest of the articulating surface is smooth and

somewhat depressed, with a large central circular canal nearly one-fifth of the whole diameter. Isolated stem-joints of a similar character and size occur in the collection from the same horizon B (K 23·262) associated with crowds of *Pleurotomaria umariensis*, and the same occur on horizon D (K 23·264).

Rhombopora sp.

Pl. 34, fig. 17.

One small fragment of a slender rod-like cylindrical bryozoan measuring about 2 mm. in length and less than 1 mm. in diameter has been recognised amongst the crumbling fragments off a large piece of rock (K 21·425). The specimen may be referred to the genus *Rhombopora* and shows on the semi-circumference exposed a few (4 or 5) rather irregular longitudinal rows of alternating large oval cell-apertures of equal size separated by rather thick rounded interapertural ridges widening below the apertures and bearing a few small spinose tubercles somewhat irregularly distributed, but usually there seems to be one below each aperture.

This zoarium resembles *Rhombopora nicklesi* Ulrich [1] from the Lower Coal measures of Illinois rather than *Rhabdomeson rhombiferum* (Phill.) [2] with which Ulrich compares this American species. Loczy [3] has figured a specimen from Teng-tjan-tsching as *Rhabdomeson* cf. *rhombiferum* which appears to possess most of the characters of our specimen, though he says that the edges of the cells are sharp and smooth. *Rhomb. Wortheni* Ulrich [4] from the Lower Carboniferous of America, *Rhomb. lepidodendroides* Meek, and *Rhomb. bigemmis* Keys. are other allied species. *Rh. tenuis* Hinde [5] from the West Australian Carboniferous may also be compared.

Productus umariensis sp. nov.

Pl. 31, figs. 1-6.
Pl. 32, figs. 4-8.

[1] Ulrich, *Geol. Surv. Illinois*, VIII, 1890, p. 661, pl. LXX, figs. 1, 1a-c.
[2] Phillips, *Geol. Yorkshire*, pl. I, figs. 34, 35.
[3] Loczy, *Beschr. Palaeont. Stratig. Result.*, Reise Bela Szechenyi in Ostasien, 1898, p. 97, t. III, fig. 22.
[4] Ulrich, *Journ. Cinnc. Soc. Nat. Hist.*, Vol. IV, 1884, p. 32, pl. 1, figs. 4, 4a, b.
[5] Hinde, *Geol. Mag.*, Dec. 3, Vol. III, 1890, p. 203, pl. VIIIA, pp. 4, 4a.

Shell transversely semielliptical to subquadrate, wider than long; hinge-line long, straight, equal to or slightly less than maximum width of shell; cardinal angles subrectangular to slightly obtuse, not produced; valves closely appressed. Pedicle-valve gently convex, not inflated, horizontally extended in cardinal region, but arched down slightly at sides and in front; body feebly convex, sometimes rather flattened in middle, sloping down gradually to depressed triangular horizontal ears which are occasionally slightly arched along the hinge-line and upturned at the cardinal angles, but are not sharply marked off from the body; hinge-line with more or less developed thickened band along its edge forming a narrow smooth false hinge-area set at right angles to the plane of the valve and usually bearing inside its edge 1-3 stout, short, straight, hollow spines, obliquely directed outwards and upwards; beak low, broad, obtuse, rounded, very slightly incurved or elevated, scarcely or not at all projecting beyond hinge-line.

Surface of pedicle-valve covered with numerous fine rounded radial riblets usually straight and of equal size and thickness, 8-10 occurring in a space of 5 mm. at a distance of 15 mm. from the beak, and increasing in number by intercalation at about one-third to one-half their length and occasionally again nearer the margin, but sometimes with a few riblets thicker than the rest for all or part of their length or as far as the base of a spine where they divide into 2-3 smaller riblets which rapidly become as thick as the others. Spine-bases on body very few and irregularly distributed, usually on the thicker riblets, sometimes more numerous in umbonal region than elsewhere. Intercostal grooves rounded, as wide or rather wider than riblets. Whole surface of shell covered with a close fine concentric striation, and having a few inconspicuous low weak rounded rugae mostly developed on the ears and posterior slopes of the body. Interior of pedicle-valve with large flabellate radially striated diductors weakly marked, extending fully half the length of the valve, having more deeply impressed posterior stalks embracing a narrow adductor scar and bounded by coarsely pitted ovarian areas on each side at base of ears. Brachial valve deeply concave, closely appressed to opposite valve, with ears more clearly marked off from body and having a gentle independent convexity; surface covered with riblets similar to those on opposite valve, but usually increasing in number by bifurcation more than by inter-

calation. Interior with low median septum extending about half the length of the valve.

Dimensions	I.	II.	III.	IV.	V.	VI.	
Width	37	35	40	40	43	34	mm.
Length	28	27	27	30	34	27	mm.
Depth	10	..	8	12	15	13	mm.

Remarks.—This species is by far the most abundant fossil in the shell-band, and it frequently forms the bulk of the rock. Detached specimens free from matrix, though rarely perfect, also occur in the later collection made by Mr. Gee. The species varies slightly in the convexity of the pedicle-valve and in the degree of elevation and overhang of the beak, but the convexity is never strong nor the beak swollen, and the general flatness and horizontal extension of the valve without any marked anterior curvature downwards are characteristic features; the presence of occasional stronger riblets and of scattered spine-bases on the surface are also typical.

Its affinities were at first thought to be with *Pr. hemisphericus* Sow.[1] of the Lower Carboniferous, and Krenkel[2] has given a figure of this species from the Tian-Shan which considerably resembles some of our shells. Davidson (op. cit.) regarded *Pr. hemisphericus* as merely a variety of *Pr. giganteus* Mart., and depicted a large number of small spines along the cardinal edge, to which feature Vaughan[3] also alludes. The latter author in noticing its close relations to *Pr. cora* (auctt.) distinguishes it by the more gradual slope of the sides, the broader and less arched beak and the stronger cylindrical rolling of the wings, as well as by the more transverse shape of the shell. Some of the shells from the Cora and Schwagerina horizons of the Urals attributed by Tschernyschew[4] to *Pr. cora* bear a great resemblance to our species in their general shape, slight convexity, small projection of the beak, thickened cardinal margin and supra-cardinal spines, but we may doubt if these Russian shells belong to the same species as the true South American *Pr. cora* D'Orb. The synonymy of this species is still a

[1] Davidson, Mon. Brit. Carb. Brach. (Palæont. Soc.), Vol. II, p. 144, pl. XL, fig. 4-9.

[2] Krenkel, *Abh. bayer. Akad. Wiss.*, Math. Phys. Kl., XXVI, Abh. 8, 1913, p. 41, t. II, fig. 1.

[3] Vaughan, *Quart. Journ. Geol. Soc.*, Vol. LXI, 1905, p. 291, pl. XXV, fig. 5.

[4] Tschernyschew, *Mem. Com. Geol. Russ.*, Vol. XVI, No. 2, 1902, pp. 279, 621, t. XXXIII, figs. 2, 3, t. XXXV, fig. 1, t. LIV, figs. 1-5.

matter of controversy [1]. We may also draw attention to the similarity of the figure of a shell from the Carboniferous of Yunnan attributed by Mansuy [2] to *Pr. cora*, while one from Cambodia [3] attributed by him to *Pr. lineatus* (which is often included in *Pr. cora*) has the same kind of ears, riblets and cardinal spines as our species, but possesses a more inflated body and more overhanging beak.

With regard to North American shells which have been referred to *Pr. cora* from various horizons in the Carboniferous or Permo-Carboniferous, some of them bear a considerable resemblance to our Umaria shell, especially some of the shells figured by Girty [4] from the Wewoka Formation of Oklahoma as *Pr. cora*, for they have the spiniferous riblets larger and more prominent than the rest. But we may particularly compare the shell figured by Hall and Clarke [5] as *Pr. auriculatus* Swallow, from the Coal Measures of Missouri, which in shape, ribbing and cardinal spines appears to be closely similar. The species termed *Pr. magnus* Meek and Worthen, [6] from the Keokuk of Illinois, seems also to have many features in common.

Amongst Australian shells referred to *Pr. cora* we may compare the variety *farleyensis* Eth. and Dun, [7] from the Lower Marine stage of New South Wales.

But it seems inadvisable to include our shells in the very varied assemblage of forms referred to *Pr. cora*, and a new specific name seems fully justified.

It may be mentioned that certain figured examples of *Pr.* (*Marginifera*) *vihiana* Diener [8] from the Zewan Beds of Kashmir, lacking a median sinus, seem to resemble *Pr. umariensis* in shape and general characters, but the latter cannot be referred to this subgenus.

[1] Hayasaka, *Science Rept. Tohoku Imper. Univ., Ser.* 2, Geol., Vol. VI, No. 1, 1922, pp. 86-93.

[2] Mansuy, *Mem. Serv. Geol. Indo-Chine*, Vol. I, fasc. 2, 1912, p. 95, pl. XVII, fig. 9.

[3] *Ibid*, Vol. III, fasc. 3, 1914, p. 18, pl. VI, figs. 2a-c.

[4] Girty, *Bull.* 544, *U. S. Geol. Surv., 1915*, p. 68, pl. VIII, figs. 4, 5 (non 6).

[5] Hall and Clarke, *Palaeont. New York*, Vol. VIII, Brach. 1, 1892, pl. XVIIA, fig. 24.

[6] Meek and Worthen, *Geol. Surv. Illinois*, III, 1868, p. 528, pl. XX, fig. 7.

[7] Etheridge and Dun, *Rec. Geol. Surv. N. S. Wales*, Vol. VIII, pt. 4, 1909, p. 302, pl. XLII, figs. 9-11.

[8] Diener, Anthrac. Faunae Kashmir, etc., *Pal. Indica*, N. S. Vol. V, pt. 2, 1915, p. 79, pl. VIII, figs. 10-12.

Productus umariensis var. *spinifera.*

Pl. 33, figs. 1-6.
Pl. 35, fig. 9.

Shell transversely subquadrate; hinge-line equal to or rather less than maximum width of shell. Body of pedicle-valve gently convex; beak rather small, not swollen, scarcely incurved, very slightly projecting behind; ears somewhat flattened, large, not sharply marked off from body but possessing a cardinal curvature; cardinal angles subrectangular or obtuse; cardinal margin more or less thickened and bearing above its edge 2-3 large stout hollow spines directed outwards and backwards nearly in plane of valve, with a few smaller spines on posterior slopes of umbo. Surface of valve covered with regular sub-equal rounded riblets occasionally swelling up into hollow spine-bases which are usually arranged in an open quincunx order, 6-10 riblets apart; each riblet beyond its spine-base divides into 2 or 3 smaller riblets which ultimately become as large as the others. Concentric rugae strong on ears, but weaker and narrower on body, meeting hinge-line at obtuse angle.

Dimensions.—Width 20-40 mm.

Remarks.—This variety seems only separable from the typical *Pr. umariensis* by the greater abundance and more regular distribution of spine-bases on the body. It is much like some specimens of *Pr. cancrini* Kut. as figured by Netschajew [1] from the Permian of Russia, but it is not like typical examples of that species. A shell from the Wewoka Formation of Oklahoma which Girty[2] described and figured as "an unusual form of *Pr. cora*" bears also a considerable resemblance. Some of the shells attributed to *Pr. cancriniformis* Tschern. by Diener [3] from Chitichun and by Schellwien [4] from the Trogkofel show many points of similarity, judging from the published figures. *Pr. pertenuis* Meek, which Girty [5] says is intimately related to *Pr. cora*, is also apparently allied, and it is specially mentioned by Tschernyschew [6] and Diener as much resembling *Pr. cancriniformis*. But the typical specimens of *Pr. cancriniformis* are much narrower, more elongated and more swollen,

[1] Netschajew, *Mem. Com. Geol. Russ.*, N. S., Livr. 61, 1911, p. 138, t. III, figs. 2-5.
[2] Girty, *Bull.* 5:4, *U. S. Geol. Surv., 1915*, p. 68, pl. VIII, fig. 6 (non 4, 5).
[3] Diener, Himal. Foss., Vol. I, pt. 3, (*Pal. Indica* Ser. XV), p. 25, pl. IV, fig. 6.
[4] Schellwien, *Abh. k. k. geol. Reichsanst.*, XVI, 1900, p. 43, t. IX, figs. 1-3.
[5] Girty, *op. cit.*, p. 75, pl. VIII, figs. 3, 3a.
[6] Tschernyschew, *Mem. Com. Geol. Russ.*, XVI, 1902, pp. 292, 629, t. III, fig. 5.

and are quite unlike the Umaria shell. The American species *Pr. pratteniamus* Norwood [1] which some authors [2] consider inseparable from *Pr. cora*, includes some shells [3] which seem to be identical in general characters with our Umaria form, but are quite distinct from the typical *Pr. cora*. The division of the riblets anterior to the base of the spines on the general surface of the shell is similar to that figured and described by Weller in an allied American species named *Pr. fernglenensis* Weller [4], from the Kinderhook Group of Illinois, and it seems to be rather a peculiar and characteristic feature.

The increased number of spines on the body is the only feature by which we can satisfactorily separate our variety from the typical *Pr. umariensis*, and there are some transitional forms in the collection. It occurs in the shell-band and on horizons A, B and C. One specimen from horizon C (K 23·263) which is here figured (Pl. 35, fig. 9) differs from the typical *spinifera* by having an unusually short hinge-line and a sub-circular rather than transverse outline to the shell, but in other respects it does not seem to show any features by which we can separate it.

Productus rewahensis sp. nov.

Pl. 32, figs. 1, 1a.
Pl. 35, figs. 1-7.

Shell transversely subquadrate to semi-elliptical, wider than long; hinge-line equal to or rather greater than width of shell. Pedicle-valve convex, more or less inflated, rounded; beak broad, obtuse, rounded, swollen, somewhat overhanging and projecting beyond hinge-line; ears rather large, triangular, rarely subacute and projecting, depressed, but not sharply marked off from the swollen body which rises with a marked independent convexity from them. Surface of valve covered with fine regular equal or subequal rounded thread-like non-spiniferous riblets increasing in number by intercalation once or twice, and numbering about 16 in a space of 10 mm.

[1] Norwood, *Journ. Acad. Nat. Sc. Philad.*, III, 1854, p. 17, fig. 10.
[2] Schuchert, *Bull.* 87 *U. S. Geol. Surv.*, 1897, p. 322.
[3] Meek, *Final Rept. Geol. Surv. Nebraska*, 1872, p. 163, pl. 8, figs. 10a, b (non cet.).
[4] Weller, *Mon. I, State Geol. Surv. Illinois*, 1914, p. 106, pl. IX, figs. 11-17.

at a distance of 10 mm. from the beak. Hinge-line occasionally thickened and furnished with 2-4 supramarginal spines.

Dimensions.	I.	II.	III.	IV.	V.
Length	27	26	26	33	28 mm.
Width	34	34	29	44	30 mm.
Depth	13	13	12	15	17 mm.

Remarks.—This shell which occurs on all the horizons varies somewhat in its proportions, some specimens being wider than others. It appears to be allied to the Russian species *Pr. Tschernyschewi* Netsch.[1], of Permian age, but differs chiefly in being less globose, shorter and more transverse, as well as in the ears being larger and rather more distinctly separated from the body and in the riblets being rather coarser. From *Pr. umariensis* it differs in the more inflated overhanging and broader beak, in the more convex and swollen body, in the greater regularity, larger number and smaller size of the riblets and in the absence of spines upon them. But it is sometimes difficult to separate the two local species, and for a long time there was hesitation in regarding them as specifically distinct. Another Russian species *Pr. planohemisphaerium* Netsch.[2] has more enrolled ears, but otherwise seems to be allied, and *Pr. latus* Netsch.[3] also shows many similar features. The shells from Chitichun which Diener[4] referred to *Pr. lineatus* Waag. bear a certain resemblance in general characters to our shell, and we may also note its similarity to the shell from the Zewan Beds of Kashmir which Diener[5] identified with *Pr. waagenianus* Girty,[6] a North American Guadelupian species closely allied to *Pr. eucharis* Girty,[7] from the Upper Carboniferous of Idaho.

In the collection from band (K 23·264) at Umaria there is one interior of a brachial valve (Pl. 35, fig. 6) showing an inner pair of short straight low very slightly divergent median ridges, and an outer pair of slightly arched strongly divergent rather longer and more elevated ridges bisecting the angle between the hinge-line and

[1] Netschajew, *Mem. Com. Geol. Russ.*, N. S., Livr. 61, 1911, p. 141 t. I, figs. 5, 7, t. II, figs. 6-11.
[2] *Ibid.*, p. 141, t. VI, fig. 6.
[3] *Ibid.*, p. 142, t. II, figs. 12, 13.
[4] Diener, *Pal. Indica*, Ser. XV, Vol. I, pt. 3, p. 14, pl. IV, figs. 2-5.
[5] Diener, Anthrac. Fauna of Kashmir, etc., (*Pal Indica,* N S, Vol. V, Mem. 2, 1915), p. 71, pl. VI, figs. 18, 19, pl. VII, fig. 6.
[6] Girty, *Prof. Paper* 58, *U. S. Geol. Surv.*, 1908, p. 253, pl. XII, figs. 6, 7.
[7] Girty, *Bull.* 436, *U. S. Geol. Surv.*, 1910, p. 28, pl. II figs. 3, 4.

the inner pair of ridges. A sharply curved narrower and lower brachial ridge of the usual type can be detected on the left side but the corresponding one on the other side is not preserved. It is probable that this specimen belongs to *Pr. rewahensis* rather than to *Pr. umariensis*, for the valve is more deeply concave and more rounded and the beak is broader and more obtuse and the ribbing finer than in the latter species. The internal cast of a pedicle-valve (Pl. 35, fig. 7) from the same band D (K 23·264) shows the flabellate diductors subcentrally divergent and with rather long parallel posterior stalks between the bases of which lie the narrow conjoint adductor impressions.

Productus rewahensis var. *coroides*.

Pl. 32, figs. 2, 2a, 3, 3a.
Pl. 35, figs. 8, 8a.

Shell subquadrate in shape, as long as wide; hinge-line rather less than maximum width of shell; cardinal angles not produced. Pedicle-valve swollen, rounded, convex, arching down uniformly at front and sides; beak very broad, rounded, swollen, obtuse, overhanging hinge-line; ears small, subtriangular, slightly enrolled and pointed but not produced, not flattened, scarcely marked off from body; hinge-line with 2-3 short blunt sub-marginal spines. Surface ornamented with numerous fine rounded radial equidistant non-spiniferous riblets of equal or subequal size, increasing in number by intercalation and occasional bifurcation, 20-25 riblets occurring in a space of 10 mm. at a distance of 10 mm. from beak. Concentric growth-ridges few, low, broad, inconspicuous or absent except in ears.

Dimensions.

	I (Pl. 35, fig. 8)	II.	III.
Length	34	38	36 mm.
Width	32	39	35 mm.
Height	22	—	—

Remarks.—This variety, of which the best example is the specimen figured on Plate 35, fig. 8, seems almost indistinguishable from some of those figured by Netschajew (op. cit.) as *Pr. Tschernyschewi* and differs from the typical *Pr. rewahensis* above described by its more subquadrate shape and relatively shorter hinge-line. Some

shells from the Pennsylvanian of Colorado which Girty[1] figures as *Pr. cora* bear a considerable resemblance, and *Pr. altonensis* Norw. and Pratt.[2] from the Lower Carboniferous of Illinois may also be compared.

Spirifer narsarhensis sp. nov.

Pl. 33, figs. 7, 7a, 7b.
Pl. 36, figs. 1-4.
variety { Pl. 33, figs. 8-10.
Pl. 36, fig. 5.

Shell transversely semielliptical to rounded subtriangular, with cardinal angles slightly rounded or obtuse and hinge-line slightly less than maximum width of shell. Pedicle-valve subtriangular, moderately convex; sinus rounded, usually shallow, well defined, continuous from beak to anterior margin with narrow more or less flattened floor often occupied by a weak median riblet, and having its more or less flattened steep sides bordered by the first lateral ribs which may or may not divide unequally at about one-third to one-half their length, the smaller inner half forming a weak narrow riblet on the side of the sinus; beak high, pointed, prominent, incurved, with concave rounded umbonal shoulders; hinge-area high, concave, triangular, lying nearly in plane of valve or gently inclined to it, striated parallel to hinge-line. Lateral lobes with 6-8 strong prominent sharply rounded or subangular ribs on each side, successively decreasing in size and strength to cardinal angles, some or most of them bifurcating unequally near their distal extremities; interspaces subangular or angular, as wide as ribs. Brachial valve rather more convex than opposite valve; beak much lower and smaller, and hinge-area much lower and narrower; surface of valve with suddenly elevated strong subquadrate median fold rather slowly widening anteriorly, flattened and grooved along the middle of its narrowed top, and having a thin weak riblet (rarely two riblets) for most of its length on each lateral slope. Lateral lobes with 6-7 ribs on each side similar to those on opposite valve, some or all of them bifurcating near their distal ends. Surface of both valves covered with strong subequidistant imbricating concentric

[1] Girty, *Prof. Paper* 16, *U. S. Geol. Surv.*, 1903, p. 364, pl. IV, figs. 3, 4.
[2] Weller, *op. cit.*, 1914, p. 124, pl. X, figs. 14-24.

lamellae crossed by a very delicate close radial striation. Interior without septa or dental plates.

Dimensions.

Width (max.)	21 mm.
Length „	17 mm.

Remarks.—There is one good complete specimen (Pl. 33, figs. 7, 7a, 7b) of this species in the first collection from Umaria (K 21·425) and three complete but poorly preserved specimens from horizon B (K 23·262) in the second collection, as well as many separate pedicle-valves, some of which show the interior. There is a noticeable variation in the development and number of bifurcated ribs on the lateral lobes, some examples having nearly all the ribs simple, and the riblets in the sinus and in the fold also vary slightly in development and strength. The minute radial striation on the surface is rarely visible, but the concentric lamellae are always conspicuous.

The generic reference of this shell has been a matter of some doubt because of its resemblance in shape and ribbing to certain species of *Spiriferina* in spite of the absence of an internal median septum in the pedicle-valve. The general characters at first led to its reference to *Spiriferina*, and it was provisionally considered to belong to *Sp. octoplicata* Sow., for in the occasional bifurcating lateral ribs it particularly resembles the variety *biplicata* Dav.[1] of the British Lower Carboniferous and the Russian Lower Permian.[2] But the typical *Sp. octoplicata*[3] has fewer lateral ribs and an angulated median fold. The typical form of the allied species *Sp. perplicata* North[4] has also an angular fold, and there are no bifurcated ribs on the lateral lobes nor any riblets in the sinus or on the sides of the fold. In the presence of these riblets we may note a resemblance to *Sp. cambodgiensis* Mansuy[5] from the Permo-Carboniferous of Indo-China, and the shape of the shell and of its sinus and fold are closely similar, but in Mansuy's species all the ribs are simple and usually fewer in number, and Colani[6] has remarked that it appears to connect several species. It may be mentioned that although *Sp. cristata* (Schloth.) (of which *Sp. octoplicata* is often

[1] Davidson, *Mon. Brit. Foss. Brach.*, Vol. II, Appendix, p. 226, pl. LII, figs. 11-13.
[2] Frederiks, *Rec. Geol. Comm. Russ. Far East*, No. 28, 1924, p. 35, t. I, fig. 15.
[3] North, *Quart. Journ. Geol. Soc.*, Vol. LXXVII, 1920, p. 215, pl. XIII, figs. 8, 9.
[4] *Ibid.*, p. 219, pl. XIII, figs. 7a-c, 10.
[5] Mansuy, *Mem. Serv. Geol. Indo-Chine*, Vol. II, fasc. 4, p. 119, pl. XIII, fig. 6; *ibid.*, Vol. III, fasc. 3, p. 24.
[6] Colani, *Bull. Serv. Geol. Indo-Chine*, Vol. VI, fasc. 5, 1919, p. 13, pl. 1, figs. 3a-c.

regarded as only a variety) has usually an angular sinus devoid of any riblets, yet Davidson records their occasional presence in some British Carboniferous examples, and we also find a riblet in some specimens [1] of *Sp. duodecimcostata* McCoy from the Carboniferous of Queensland. We cannot, however, fail to notice in our Umaria shells many features which are possessed by some of the shells referred by Davidson [2] to *Spirifer grandicostatus* McCoy, such as the shape of the shell, the bifurcation of some of the lateral ribs and the presence of riblets on the fold and in the sinus. Tschernyschew [3] believed that *Sp. rectangulus* Kut. from the Upper Carboniferous of Russia, was closely allied to *Sp. grandicostatus*, but none of his figured specimens much resemble our Umaria form. The latter is more like some specimens attributed by Licharew [4] and Netschajew [5] to *Spirifer Blasii* De Vern. from the Russian Permian, which is admitted to be a very variable species, but Mansuy's [6] variety of it from the Permian of Yunnan is quite different. *Spirifer Leidyi* Norw. and Pratt.,[7] of the Chester Limestone of North America, bears a much greater resemblance in its shape, ribbing and ornamentation, than any of the above mentioned, and *Sp. pellaensis* Weller [8], also from the Lower Carboniferous of North America, is another allied species. But our species has a less strongly divided median fold in the brachial valve than *Sp. Leidyi*, and its lateral ribs are more commonly bifurcated. There is a species from the Fenestella Series of Kashmir described by Diener as *Spirifer Middlemissi* [9] and regarded as closely allied to *Sp. grandicostatus* McCoy, which is almost indistinguishable from our Umaria form. But the fold is stated to be divided by three principal ribs of which the central one is the largest, instead of the fold having a median groove, though the occasional bifurcation or trifurcation of the 7-10 lateral ribs and the lamellose character

[1] De Koninck, Descr. Palæoz. Foss. N.S. Wales (transl. E. David), *Mem. Geol. Surv. N.S. Wales, Palæont.* No. 6, 1898, p. 182, pl. XII, fig. 4 and footnote.

[2] Davidson, *op. cit.*, pp. 33, 222, pl. VII, figs. 7-16.

[3] Tschernyschew, *op. cit.*, 1902, p. 545, t. VIII, fig. 1, t. XLI, figs. 1-5.

[4] Licharew, *Mem. Com. Geol. Russ.*, N. S., Livr. 85, 1913, p. 54, t. III, figs. 9, 11.

[5] Netschajew, *ibid.*, Livr. 61, 1911, p. 82, t. XII, figs. 9, 10.

[6] Mansuy, *Mem. Serv. Geol. Indo-Chine*, Vol. I, fasc. 2, 1912, p. 114, pl. XXII, figs. 2a-e.

[7] Norwood and Pratten, *Journ. Acad. Nat. Sc.,Philad.*, III, 1854, p. 72, pl. 9, fig. 2; Weller, *op. cit.*, 1914, p. 345, pl. XLVII, figs. 17-31.

[8] Weller, *op. cit.* 1914, p. 340, pl. XLV, figs. 1-31.

[9] Diener, Anthrac. Faunae of Kashmir, Kanaur and Spiti. *Pal., Indica*, N. S., Vol. V, Mem. 2, 1915, p. 41, pl. IV, figs. 9-12.

of the test agree precisely with our new species. The sinus in the pedicle-valve of *Sp. Middlemissi* is said to be narrow and to be divided by one or two longitudinal ribs, and in the allied species *Sp. Varuna* Diener,[1] these ribs are more numerous, and Diener mentions its resemblance to *Sp. Blasii*. The reduction in the angularity and number of the lateral ribs, their simplicity and the more rounded outline of the shell lead us by intermediate forms (Pl. 33, figs. 8-10, Pl. 36, fig. 5) to the fairly distinct variety described below.

On the whole the affinities of *Sp. narsarhensis* are more with *Sp. grandicostatus*, *Sp. Middlemissi* and *Sp. Leidyi* than with any others.

Spirifer narsarhensis var. *pauciplicata*.

Pl. 33, fig. 11.
Pl. 36, figs. 6, 7.

Shell transversely oval to elliptical; cardinal angles well rounded, hinge-line less than maximum width of shell. Pedicle-valve gently convex, more so than opposite valve; beak scarcely elevated above hinge-line, incurved; hinge-area small, low, triangular, concave, steeply inclined to plane of valve; median sinus rounded, deep, with steeply sloping sides and narrow flat floor, usually without a weak median rounded riblet and rarely with a shorter narrower lateral one on each slope; lateral lobes with 4-7 rounded or slightly subangular strongly elevated simple ribs decreasing successively in size towards the cardinal angles (near which they are occasionally obsolete) and separated by wide rounded interspaces as wide as or wider than the ribs. Brachial valve with subquadrate narrow high median fold suddenly elevated, more or less flattened on top rarely grooved and not wider than two of the adjacent ribs, rarely having weak narrow riblets on its steep slopes; lateral lobes with 4-7 ribs on each side similar to those of opposite valve; beak small, obtuse, low. Surface of shell covered with strong regular concentric overlapping lamellae, usually equidistant, and crossed by very delicate radial striation.

Dimensions.

	Brachial valves. I.	II.	III.
Length	13·0	9·5	17·0 mm.
Width	18·5	16·0	24·0 mm.

[1] *Ibid.*, p. 43, pl. 34, figs., 13-15.

Remarks.—As above remarked this variety is connected with the typical *Sp. narsarhensis* by passage-forms. But in extreme examples the ribs are further apart, wider and fewer in number, the shell is more rounded and elliptical in shape, and the ribs are always simple, so that certain forms seem sufficiently different to deserve a varietal name (*pauciplicata*) though they occur associated with the type of the species in the same beds. Mr. E. R. Gee has collected a considerable series of specimens, mostly of isolated valves, from horizon B, and they are in several cases in a good state of preservation. It seems as if this variety were more like *Spirifer bifurcatus* Hall,[1] than *Sp. Leidyi* Norw. and Pratt., though Schuchert[2] put them as synonyms. The original example from Umaria (Pl. 33, fig. 11) was much crushed and imperfect and was at first identified as *Spiriferina cristata* Schloth.

Reticularia barakarensis sp. nov.

Pl. 34, figs. 1-9, 10 ?

Pl. 36, figs. 8-11.

Shell subcircular to transversely subelliptical, gently biconvex; hinge-line short, less than width of shell. Pedicle-valve moderately convex, with strong rounded broad median sinus extending from the beak to the anterior margin increasing in width, well defined by low sharply rounded edges or weak folds and having rather steep sides and the floor projecting in front as a short rounded tongue; beak rather suddenly elevated, small, high, prominent, acutely pointed, sharply incurved, with sides somewhat excavated and diverging at less than 90°; delthyrium triangular, open; hinge-area gently concave, triangular, not sharply defined at sides. Interior of pedicle-valve with straight or slightly arched thin dental plates, scarcely divergent and extending about one third the length of the shell. Brachial valve with low median rounded fold and small inconspicuous beak. Surface of valves covered with narrow regular closely-placed thin concentric lamellae of fairly equal width covered with a dense felt of closely placed minute radial equidistant hollow flattened recumbent spinules usually alternating on successive lamellae and resulting in a regular fimbriation of surface

[1] Weller, *op. cit.*, p. 346, pl. XLVII, figs. 6-16.
[2] Schuchert, *Bull.* 87, *U. S. Geol. Surv.*, 1897, p. 395,

in the middle part of the valves but radially arranged on the flanks and thus giving in these parts the appearance of radial lineation.

Dimensions.	I.	II.
Length	30	28 mm.
Width	32	30 mm.

Remarks.—The true reference of this fossil was a matter of much difficulty in the case of the first specimens submitted to me, as only broken valves or impressions of parts of the surface were available, and the appearance of the ornamentation differs much according to the state of preservation and its position on the shell. In cases where the shell is rubbed the surface looks as if it were pitted, the spaces left by the spine-bases forming minute lanceolate or oval pits. Most of the specimens are crushed or distorted, but the further material obtained by Mr. E. R. Gee from Horizon B is in a better state of preservation, so that the external characters of the species can be quite satisfactorily determined.

The resemblance of this shell to many of those referred to *Spirifer lineatus* Mart., such as that one described and figured by De Koninck[1] from the Permo-Carboniferous of New South Wales, is at once apparent. But the typical *Sp. lineatus* Mart. of the European Lower Carboniferous and the shells from the Productus Limestones of the Salt Range referred to that species by Waagen,[2] are quite different, the broad median sinus in the pedicle-valve of our form being particularly noticeable and distinctive. There has been much latitude in the use of the specific name *lineatus*, and the species has been frequently recorded from Upper Carboniferous or Permian beds in Asia[3] and elsewhere, though we may doubt the accuracy of all the identifications. Thus the American shell *Squamularia perplexa* McChesney[4] has frequently been mistaken for it in the past, being externally not unlike many of the shells referred to Martin's *Reticularia lineata*, but Girty[5] is led to believe that *Squamularia* has no internal plates and thereby is generically separable from

[1] De Koninck, Palæoz. Foss, New South Wales (transl. by Edgeworth David) *Mem. Geol. Surv., N. S. Wales*, Palæont. No. 6, 1898, p. 174, pl. XI, fig. 9.

[2] Waagen, Salt Range Foss. I, (*Pal. Indica*, Ser. XIII), p. 540, pl. XLII, figs. 6-8.

[3] Broili, *Perm. Brach. Timor* (*Paläont. Timor*, Lief. VI, Abt. XII, 1916), p. 40, t. 121, figs. 4, 6-8, t. 122, figs. 1-16; Hayasaka, *Science Rept. Tohoku Imper. Univ.*, Ser. 2, Geol., Vol. VIII, No. 1, 1924, p. 51, pl. VI, figs. 15, 16.

[4] Girty, *Bull.* 544, *U. S. Geol. Surv.*, 1915, p. 92, pl. XI, figs. 1-3a.

[5] Girty, *in* Willis and Blackwelder '*Research in China*', (*Carnegie Instit.*), Vol. III 1913, pp. 300, 322.

Reticularia. The resulting confusion has been recently mentioned by the present author [1] in describing specimens from the Upper Carboniferous of Chitral, and Girty,[2] Buckman,[3] Hayasaka [4] and other writers in late years have alluded to the difficulty of separating the many forms or varieties grouped under the designation *Sp. lineatus*, and there is little agreement in their views. Thus Hayasaka (op. cit.) considers that one of the distinguishing features of *Squamularia* is the possession of a ventral sinus which is absent in *Reticularia*. But this does not conform with Davidson's opinion, for he included the sinuated *Sp. mesoloba* Phill. in *R. lineata*. Girty and Kozlowski [5] likewise differ. It should be also mentioned that though Waagen [6] states that *Reticularia* has no dental plates, Girty regards their presence in this genus as the important and critical character distinguishing it thereby from *Squamularia*. Frederiks,[7] however, includes Broili's examples of *R. lineata* from the Permian of Timor in his synonymy of *Squamularia perplexa* McChesney. The examples of *R. lineata* figured by Diener [8] from the Himalayas or those of this species and its allies figured by Mansuy [9] from the Productus Limestone of Indo-China do not represent a shell identical with the present one from Umaria. The Russian species *R. rostrata* (Kut.) [10] is also different, but the Sicilian *R. affinis* Gemm. with which Diener [11] ultimately compared some of the Chitichun specimens, bears more resemblance to our form.

There is a shell from the Carboniferous Limestone of Ireland which McCoy named *Reticularia reticulata* [12] which agrees with our shell in the presence of a median fold and sinus, as well as in the general ornamentation of the surface, but it cannot be considered

[1] Reed, Upper Carb. Foss. Chitral, (*Pal. Indica*, N.S. Vol. VI, Mem. No. 4, 1925), p. 83.

[2] Girty, *Prof. Paper* 58, *U. S. Geol. Surv.*, 1908, p. 366.

[3] Buckman, *Quart. Journ. Geol. Soc.*, LXIV, 1908, p. 33.

[4] Hayasaka, *op. cit.*, Vol. VI, No. 1, 1922, p. 129.

[5] Kozlowski, *Annales de Paléont.* IX, 1914, p. 73, text fig. 18.

[6] Waagen, Salt Range Foss. I, (*Pal. Indica.* Ser. XIII), pp. 538, 540, pl. XLII, figs. 6-8.

[7] Frederiks, *Rec. Geol. Comm. Russ. Far East*, No. 28, 1924, I, Brach., p. 47.

[8] Diener, Himal. Foss. (*Pal. Indica*, Ser. XV), Vol. I, pt. 3, 1897, p. 57, pl. IX, figs. 5-8.

[9] Mansuy, *Mem. Serv. Geol. Indo-Chine*, Vol. II, fasc. 4, 1913, pp. 80-82, pl. IX, figs. 1-3.

[10] Tschernyschew, *Mem. Com. Geol. St. Petersb.*, XVI, 2, 1902, pp. 194, 575, t. XV, figs. 4, 5; t. XX, figs. 14-18.

[11] Diener, *op. cit.*, Vol. I, pt. 5, 1903, p. 19.

[12] McCoy, *Syn. Carb. Foss. Ireland*, 1844, p. 143, pl. XIX, fig. 15.

identical. The typical *R. imbricata* Phill.[1] from the Carboniferous Limestone of Yorkshire, is also closely similar in external characters. But Davidson [2] regarded the Irish species as a synonym of *R. lineata* Mart. and the Yorkshire one as being merely of varietal rank.

With greater success we may compare our Umaria species is more comparable with *R. setigera* Hall,[3] and to a lesser degree with *R. pseudolineata* Hall [4] and *R. salemensis* Weller [5] from the Lower Carboniferous of the United States than with any of the foregoing species.

Reticularia barakarensis var. *subplicata.*

Pl. 36, figs. 12, 13.

Shell transversely elliptical. Pedicle-valve gently convex, having a shallow broad rounded median sinus rapidly increasing in width anteriorly with its floor somewhat flattened and bearing a faint narrow median groove and projecting as a short rounded tongue. On each side of the sinus a low broad rounded radial fold occupies nearly half of each lateral lobe, and there is a second similar but narrower and weaker radial fold outside it occupying half the remaining space to the cardinal margin, the folds being marked off by shallow sharply impressed slightly curved radial grooves; beak small, low, rising a little above hinge-line, acutely pointed, incurved. Surface of shell covered with numerous thin concentric lamellæ having short adjacent recumbent radial spinules producing a minute fimbriation and lineation.

Dimensions.

Length	31 mm.
Width	38 mm.

Remarks.—This variety (of which there is only one good specimen showing the lateral radial folds and another crushed one with the folds scarcely discernible, both from Horizon B, K 23·262) differs from *R. barakarensis* not only by the presence of these lateral folds but also by the shallower less sharply defined grooved sinus, the

[1] Phillips, *Geol. Yorkshire*, 1836, p. 219, pl. X, fig. 20.
[2] Davidson, *Brit. Foss. Brach.*, Vol. II, 1857, p. 62, pl. XIII, figs. 11-13; *ibid.*, Vol. IV, pt. 3, 1880, p. 275.
[3] Hall and Clarke, *Palæont. New York*, VIII, Brach. II, pl. 36, figs. 26, 27. Weller, *op. cit.*, 1914, p. 431, pl. LXXIV, figs. 12-22. Girty, *Bull.* 593, *U. S. Geol. Surv.*, 1915, p. 65, pl. IV, fig. 6.
[4] Hall and Clarke, *op. cit.*, pl. 36, figs. 28, 30.
[5] Weller, *op. cit.*, 1914, p. 433, pl. LXXV, figs. 15-19.

more transverse shape of the shell and the lower and smaller beak to the pedicle-valve. The ornamentation seems to be identical. The presence of a sinus and median fold with a few broad rounded lateral radial folds with a similar shape to the shell are found in *Reticularia fimbriata* Conr.[1] of the Devonian, and Miss Muir Wood has recently described a Lower Carboniferous species from Yorkshire under the name *R. lobata*[2] having the same general characters. Apart from the ornamentation of the surface, the young example of *Sp. Darwini* Morr. figured by De Koninck[3] from the marine Permo-Carboniferous of New South Wales, and the Russian Upper Carboniferous species *Sp. supracarbonicus* Tschern.[4] bear a considerable resemblance to our shell in the weak rounded broad lateral folds and in general shape.

Athyris aff. *protea,* Abich.

Pl. 34, fig. 11.

There is one imperfect specimen of a pedicle-valve of a brachiopod which seems closely to resemble the shell from the Kuling Shales of the Himalayas which Diener[5] has figured as *Athyris* [*Spirigera*] *protea* Abich, var. *alata.* Our example seems to have been subcircular in shape; the subangular edges of the sinus are elevated into narrow low folds, and the floor of the sinus is somewhat angulated posteriorly, though rounded anteriorly; the lateral lobes are somewhat flattened or slightly concave, and numerous weak concentric growth lamellae cross the whole surface. *A. protea* and its varieties were first described from the Otoceras beds of Djulfa, Armenia.

Orthotichia ? sp.

Pl. 33, figs. 12, 12a.

There is a much weathered valve of a large brachiopod (K 21·424) having the surface of the shell mostly destroyed, but showing internally a pair of rather long dental (?) plates which at first converge

[1] Hall and Clarke, *op. cit.*, pl. 36. figs. 17-22.

[2] Muir Wood, *Quart. Journ. Geol. Soc.*, LXXXI, 1926, pt. 2, p. 242, pl. XVI, figs. 1a-c, 2.

[3] De Koninck, *op. cit.* (*transl.*) 1898, p. 179, pl. X, figs. 11, 11a.

[4] Tschernyschew, *Mem. Com. Geol. Russ.* XVI, 1902, p. 553, t. XV, figs. 2, 3.

[5] Diener, Himal. Foss., Vol. I, pt. 5, 1903, (*Pal. Indica,* Ser. XV), p. 185, pl. IX, figs. 5a-d.

for a short distance and then diverge for the greater part of their length at an angle of about 30°. The shell was apparently subquadrate, moderately convex, most so posteriorly, with a weak very broad median sinus or depression anteriorly; the hinge-line is straight, and the beak is broad, obtuse, rounded, and slightly incurved; the cardinal angles which are imperfectly preserved were apparently rounded or obtuse. The pair of supposed dental-plates reach about one fifth the length of the shell. The surface shows traces of having possessed radial filiform striae, with concentric rugae or lamellæ on the flanks.

It was at first thought that this specimen was attributable to some species of *Orthothetes* such as *O. guadalupensis* Shum.[1] and *O. Kraffti* Diener,[2] but it seems more likely to belong to some species of *Orthotichia*, *Schizophoria* or *Enteletoides*, especially resembling *E. rossicus* Stuck.[3] from the Upper Carboniferous of Samara. Its generic reference is, however, a matter of doubt.

Indeterminable brachiopod (genus uncertain).

Pl. 35, fig. 10.

There is a small fragmentary brachiopod from Horizon. A. (K 23·261) represented by only one very imperfect specimen, 5-6 mm. long, which is different from any of those above described. It was apparently of a subquadrate or subcircular shape with a flattened surface bearing a weak median depression and about 16-18 strong straight radiating rounded ribs with scabrous ? elevations; the beak is small and rounded. In some respects it resembles *Strophalosia costata* Waag.[4] from the Lower Productus Limestone of the Salt Range, and *Aulosteges percostatus* Diener [5] of the Fenestella Series of Kashmir, but it may be merely a crushed pedicle-valve of some rhynchonelloid referable to *Liorhynchus*, *Camarotœchia* or *Camarophoria*.

[1] Girty, *Prof. Paper* 58, *U. S. Geol. Surv.*, 1908, p. 199, pl. X, figs. 1-5.
[2] Diener, Himal. Foss., Vol. I, pt. 5, 1903 (*Pal. Indica*, Ser. XV), p. 78, pl. III, figs. 6, 7.
[3] Stuckenberg, *Mem. Com. Geol. Russ.*, N. S., Livr. 23, 1905, pp. 60, 129, t. VI, fig. 8.
[4] Waagen, Salt Range Foss., I (*Pal. Indica*), p. 655, pl. LXIII, figs. 7, 8, pl. LXIV, figs. 1a-g.
[5] Diener, *Pal. Indica*. N. S., Vol. V, Mem. 2, 1915, p. 31, pl. III, figs. 4-7.

Janeia aff. *biarmica* (De Verneuil).

Pl. 36, fig. 14.

There is one small lamellibranch in the collection represented only by one right valve, and a fragment of another, both from Horizon D (K 23·264). The better specimen is suboblong in shape, abruptly truncated behind, but broadly rounded in front; the upper and lower edges are nearly straight and parallel; the beak is small broad low obtuse and situated far forward (but the anterior end of the valve is not well exposed); the valve is very slightly convex and has a broad very shallow median transverse depression crossing it obliquely; a weak low straight umbonal ridge runs back to the posterior lower angle, and above it the valve is somewhat flattened with traces of a narrow radial ridge on it; the whole surface of the valve is marked by concentric growth-lines and ridges of rather unequal strength which meet the hinge line nearly at right angles.

Dimensions.

Length	c.	5 mm.
Height.	c.	3 mm.

Affinities.—From the general shape and characters of this shell it seems probable that it should be referred to some species of *Janeia* or *Solemya* rather than to *Allorisma, Sphenotus* or *Sanguinolites,* though it is shorter and broader than usual in that genus. It somewhat resembles the Himalayan shell referred by Diener[1] to *Janeia biarmica* (De Vern.). *Sph. vulgaris* Girty,[2] also may perhaps be allied.

Pleurotomaria umariensis sp. nov.

Pl. 34, figs. 12, ? 13.
Pl. 35, figs. 11-13.

Shell small, turreted to sub-turbinate, conical, composed of 5-7 rounded or slightly subangular whorls increasing rather rapidly in size, bearing a broad submedian slit-band on the periphery; apical angle 45° or rather less. Whorls rather flattened above and rounded below;

[1] Diener, Himal. Foss. Vol. I, pt. 5, 1903, (*Pal. Indica*), p. 173, pl. VIII, figs. 7a, b, 8 ?

[2] Girty, *Bull.* 593, *U. S. Geol. Surv.*, 1915, p. 78, pl. VIII, figs. 5-7.

surface crossed by rather strong regular transverse fine lines meeting the slit-band on the lower surface at about 60° or more and on the apical surface at about 45°, but abutting against the suture line at right angles. Slit-band conspicuous, submedian, situated slightly below the middle of the whorls, rather deeply sunk between strong raised prominent edges and having its gently concave surface crossed by regular closely placed slightly curved lunulae. Body-whorl rounded below, large, being one third (or more) the height of the spire ; base convex, deep, generally with a weak revolving keel a short distance below the slit-band. Mouth subcircular; columellar lip nearly straight, slightly thickened and flattened, sharply exsert. Umbilicus absent.

Dimensions (average).

Height	8 mm.
Diameter of basal whorl.	5 mm.

Remarks.—All the first examples (K 21·425) from the shell-band and the associated soft greenish shales were crushed and imperfect, except one small turbinate specimen (Pl. 34, fig. 13) which had an unusually low spire and wide apical angle and is doubtfully referable to this species. But Mr. Gee has since collected a large number of specimens from the lowest band D (K 23·464) and from K 22·972, 973, of the railway cutting, in which the species is extraordinarily abundant, and the specimens are often well preserved.

With regard to the characters of the species we may observe that the apical angle varies somewhat, some shells being broader and having a lower spire than others, but otherwise agreeing in every detail. The ornamentation is constant, except as regards the one revolving lira on the body-whorl, which may be absent and is always weak.

Diener [1] has described but not figured an unnamed species of *Pleurotomaria* from the Carboniferous beds of Lipak which seems to agree closely with the Umaria form. The figures and description of *Pleurotomaria delawarensis* Girty [2] from the Guadelupian fauna of the United States may be compared with our species, and there seems to be also a considerable resemblance to *Pl. kirillowensis*

[1] Diener, *Pal. Indica*, N. S., Vol. V, Mem. 2, 1915, p. 119.
[2] Girty, *Prof. Paper* 58, *U. S. Geol. Surv.*, 1908. p. 475, pl. XXIII, figs. 28-30.

Licharew [1] from the Permian of Russia. But perhaps *Pl. arkansana* Girty [2] from the Batesville Sandstone is more closely allied.

The precise subgeneric reference of our species is uncertain, but it may belong to *Ptychomphalina.*

Jonesina ? sp.

Pl. 34, fig. 14.

The entomostracan genus *Jonesina* is probably represented by a small suboval gently convex body rather wider at one end than the other, and of a slightly bean-shaped outline owing to a weak concavity near the middle of the upper margin which is rather shorter than the gently arched lower margin. The surface bears a small oval very faintly elevated subcentral swelling situated behind the middle and surrounded by a fine impressed line. In front of and in contact with this swelling and likewise very faintly circumscribed is a smaller less distinct subcircular eminence scarcely raised above the general surface.

Cytherella ? sp.

Pl. 34, fig. 16.

The carapace of another small ostracod is seen in a marginal view of the two conjoint valves showing a simple junction. The shell is ovate in shape and the valves seem to be equally convex and smooth. Probably this is referable to the genus *Cytherella,* and it seems to resemble in the inflation of the valves the species '*Cythere*' *inflata* McCoy.[3]

Palaeocypris ? sp.

Pl. 34, fig. 15.

A third type of ostracod is represented by one somewhat crushed valve. It is suboval in shape, rather blunter and broader at one end than the other, and its strongly convex surface is covered with rather widely separated small sharp granules of two or three sizes. Probably this is referable to the genus *Palaeocypris.*

[1] Licharew, *Mem. Com. Geol. Russ.*, N.S. Livr. 85, 1913, pp. 12, 87, t. V, figs. 3, 4.
[2] Girty, *Bull.* 593, *U. S. Geol. Surv.*, 1915, p. 113, pl. XI, fig. 8.
[3] McCoy, *Syn. Carb. Foss. Ireland,* 1844, p. 167, pl. XXIII, fig. 17.

Dermal tubercles of a fish.

Pl. 35, figs. 14-18a.

There are several specimens of a curious little pointed capuliform solid object (K 23·262) (K 23·264) (K 22·973) having a high rounded obliquely conical shape with a more or less sharply pointed straight or slightly curved apex directed backwards; the posterior slope below the apex is somewhat hollowed; the base of the tubercle is somewhat expanded and flattened, with a circular to suboval outline, but is thin and without any root. The cone appears to be solid, but the base of it is slightly excavated underneath. The surface of the cone is covered with small low closely-placed rounded granules. The largest specimen measures about 8 mm. in height and has the same diameter at the base. We may probably interpret this fossil as the dermal tubercle of some selachian and of the same nature as *Petrodus*. Sir A. Smith Woodward thinks it is a new genus.

AFFINITIES OF THE FAUNA AND CORRELATION OF THE BEDS.

The fauna of these Umaria beds has a striking individuality of its own, and it comprises only a few genera. The majority of the fossils are brachiopods, belonging to the genera *Productus*, *Spirifer* and *Reticularia*, the first named genus largely predominating. The species are found to be in all cases new when the material is sufficiently well preserved for their specific identification, and their affinities are not particularly close with any previously described forms, though their nearest relations are partly found amongst Himalayan and Russian species of Permo-Carboniferous and Permian age and partly amongst Carboniferous species. Thus *Productus umariensis* and its variety *spinifera* recall forms referred to *Pr. cora* and *Pr. cancriniformis*, while *Pr. rewahensis* seems allied to *Pr. Tschernyschewi* of the Russian Permian. *Spirifer narsarhensis* on the other hand is more like *Sp. grandicostatus*, *Sp. Middlemissi* and *Sp. Leidyi*, all occurring in the Carboniferous of other regions, while *Reticularia barakarensis* seems to have its nearest relative in *R. setigera* of the Lower Carboniferous of America. But the species of *Athyris* and the lamellibranch referred to *Janeia* are more allied to Permian species. The other fossils are hardly well enough known for any stratigraphical conclusions to be drawn from them.

The distribution of the species on the several horizons recognised by Mr. Gee does not suggest any important difference in the age of these bands, and most of the species seem common to them all.

For the association of marine fossiliferous beds with typical Gondwana plant-bearing series we have to go to Kashmir and Australia. In the case of Kashmir the Zewan (Permo-Carboniferous) Beds which contain a Productus Limestone fauna rest on the Gangamopteris Beds of the Lower Gondwana which in their turn repose on the Panjal Volcanics and Agglomeratic Slate of possible Talchir age. Below these volcanic beds are marine Carboniferous beds, the uppermost of which is known as the Fenestella series and is doubtfully referred to the Middle Carboniferous by Middlemiss.[1] The Syringothyris Limestone series which lies below is separated from the Fenestella series by some passage beds, and is definitely ascribed to the Carboniferous. But neither the fauna of the Fenestella nor of the Syringothyris beds, and even less that of the Zewan beds, shows any close general resemblance to that under consideration, though certain of the species are allied. In the Umaria locality the marine beds rest with a slight unconformity on the Talchir beds and pass up without a break into the Barakar stage of sandstones and coals which is at the base of the Damuda series. Wadia [2] places the Barakar stage in the Middle Permian, but Cotter [3] refers it to the Lower Permian. We might therefore expect *a priori* that the marine band at its base would perhaps correspond with the Karharbari which Wadia terms Permo-Carboniferous. Cotter correlates the beds of the Australian marine series which have plant-bearing deposits of Lower Gondwana type between and above them with the Karharbari series. It may be suspected that this marine bed at Umaria is of rather different date, but it cannot be considered to correspond with the Lipak or Po series of Spiti,[4] or the Fenestella series of Kashmir of which the faunas have been described by Diener.[5]

The importance of the discovery of a marine fossiliferous deposit below part of the Lower Gondwanas of Central India is obvious

[1] Middlemiss, *Rec. Geol. Surv. Ind.* Vol. XL, pt. 3, 1910, pp. 210, 222-232.
[2] Wadia, "Geology of India," 2nd edit., London, 1926, p. 116.
[3] Cotter, *Rec. Geol. Surv. Ind.*, XLVIII, 1917, pp. 23-33.
[4] Hayden, Geology of Spiti, *Mem. Geol. Surv. Ind.*, Vol. XXXVI, pt. 1, 1904, pp. 37-50; Wadia, *op. cit.*, pp. 99, 100.
[5] Diener, Himal. Foss., Vol. I, pt. 2, 1899, *Pal. Indica*, Ser. XV; *ibid.*, vol. 1. pt. 5, 1903; *ibid.*, N. S., Vol. V, Mem. 2, 1915.

from a palæogeographical point of view. For it has been generally believed that the Peninsula was a land-area from at any rate the close of the Purana (Pre-Cambrian) era until late in Aryan (Palæo-Mesozoic) times and that it was never invaded, much less wholly submerged, by the sea till the Jurassic or Cretaceous period and even then it was only along the margins that marine incursions took place. In the light of the marine fossils at Umaria we can no longer maintain this opinion in its entirety, though to what extent the sea penetrated into the land cannot at present be determined. A partial submergence is, however, proved to have occurred, and the transgression which only lasted a short time was probably either from the north through Rajputana or from the west coast.

The evidence of the fossils inclines us to conclude that this marine invasion took place in Permo-Carboniferous times, as there is a noticeable admixture of types possessing affinities with both Carboniferous and Permian species. A study of the Carboniferous Permo-Carboniferous and Permian marine faunas in the Calcutta Museum confirms the author's conclusion that this Umaria fauna is distinct and unique.

EXPLANATION OF PLATES.

PLATE 31.

FIG. 1.—*Productus umariensis* sp. nov. Pedicle-valve of nearly complete specimen. × 1½. (K 21·426).

FIG. 1a.—*Productus umariensis* sp. nov. Brachial valve of same specimen. × 1½.

FIG. 1b.— Ditto. Cardinal view of same specimen. × 1½.

FIG. 2.— Ditto. Posterior part of pedicle-valve of another nearly complete specimen. × 1½. (K 21·424).

FIG. 2a.—*Productus umariensis* sp. nov. Cardinal view of same specimen showing cardinal thickening and spines. × 1½.

FIG. 2b.—*Productus umariensis* sp. nov. Brachial valve of same specimen, showing bifurcation of riblets. × 1½.

FIG. 3.—*Productus umariensis* sp. nov. Pedicle-valve of a shell devoid of spines on riblets, some of which are thickened. × 1½. (K 21·424).

FIG. 4.—*Productus umariensis* sp. nov. Cardinal view of another example without thickened riblets. showing cardinal spines. × 1½. (K 21·424).

FIG. 4a.—*Productus umariensis* sp. nov. Ventral view of same specimen. × 1½.

FIG. 5.— Ditto Median portion of surface of pedicle-valve, showing increase of riblets by division of thicker riblet below spine-base. × 6. (K 21·424.)

FIG. 6.—*Productus umariensis* sp. nov. Lateral portion of another shell, showing increase of riblets by intercalation and without spine-bases. × 2. (K 21·426.)

PLATE 32.

FIG. 1.—*Productus rewahensis* sp. nov. Pedicle-valve, partly buried in matrix, × 1½. (K 21·424.)

FIG. 1a.—*Productus rewahensis* sp. nov. Posterior view of same specimen. × 1½.

FIG. 2.—*Productus rewahensis* var. *coroides.* Pedicle-valve of complete shell. Nat. size. (K 21·424).

FIG. 2a.—*Productus rewahensis* var. *coroides.* Brachial valve of same specimen. Nat. size.

FIG. 3.—*Productus rewahensis* var. *coroides.* Another specimen, pedicle-valve. × 1½. (K 21·424.)

FIG. 3a.—*Productus rewahensis* var. *coroides.* Portion of surface of same specimen. × 4.

FIG. 4.—*Productus umariensis* sp. nov. Interior of pedicle-valve. × 1½. (K 21·426.)

FIG. 5.—*Productus umariensis* sp. nov. Posterior part of pedicle-valve of another specimen. × 1½. (K 21·424.)

FIG. 6.—*Productus umariensis* sp. nov. Brachial valve of complete shell. × 1½. (K 21·424.)

FIG. 7.—*Productus umariensis* sp. nov. Pedicle-valve of another specimen. × 1½. (K 21·424.)

FIG. 8.—*Productus umariensis* sp. nov. Brachial valve of a complete shell. × 1¼. (K 21·424.)

PLATE 33.

FIG. 1.—*Productus umariensis* var. *spinifera.* Pedicle-valve nearly complete, showing spines on surface. × 1½. (K 21·424.)

FIG. 1a.—*Productus umariensis* var. *spinifera.* Part of centre of surface of same shell. × 4.

FIG. 1b.—*Productus umariensis* var. *spinifera.* Part of surface of same shell near lateral margin. × 4.

FIG. 2.—*Productus umariensis* var. *spinifera.* Imperfect pedicle-valve with fewer spines. × 1½. (K 21·424.)

FIG. 3.—*Productus umariensis* var. *spinifera.* Posterior part of another pedicle-valve. × 1½. (K 21·424.)

FIG. 4.—*Productus umariensis* var. *spinifera.* Posterior part of pedicle-valve of another specimen, showing cardinal spines. × 1½. (K 21·424.)

FIG. 5.—*Productus umariensis* var. *spinifera.* Posterior part of pedicle-valve of another specimen, showing cardinal spines. × 2. (K 21·424.)

FIG. 5a.—*Productus umariensis* var. *spinifera.* Cardinal view of same specimen. × 2.

FIG. 6.—*Productus umariensis* var. *spinifera.* Fragment of interior of pedicle-valve, showing vascular markings outside diductor scars. × 1¼. (K 21·424.)

FIG. 7.—*Spirifer narsarhensis* sp. nov. Complete specimen, dorsal view. × 2. (K 21·425.)

FIG. 7a.—*Spirifer narsarhensis* sp. nov. Ventral view of same specimen. × 2.

FIG. 7b.— Ditto. Anterior marginal view of same specimen. × 2.

FIG. 8.—*Spirifer narsarhensis* var. Imperfect pedicle-valve. × 2. (K 21·424.)
FIG. 9.— Ditto. var. Imperfect brachial valve. × 2. (K 21·425.)
FIG. 10.— Ditto. var. Imperfect pedicle-valve. × 2. (K 21·425.)
FIG. 11.—*Spirifer narsarhensis* var. *pauciplicata.* Imperfect brachial valve. × 2 (K 21·424.)
FIG. 12.—*Orthotichia* ? sp. Imperfect pedicle-valve. × $1\frac{1}{4}$. (K 21·424.)
FIG. 12a.—*Orthotichia* ? sp. Cardinal view of same specimen, showing dental plates. × $1\frac{1}{4}$.

PLATE 34.

FIG. 1.—*Reticularia barakarensis* sp. nov. Pedicle-valve with worn surface. × $1\frac{1}{2}$ (K 21·424.)
FIG. 1a.—*Reticularia barakarensis* sp. nov. Portion of surface of same specimen with spinules abraded. × 7.
FIG. 2.—*Reticularia barakarensis* sp. nov. Imperfect brachial valve. × $1\frac{1}{2}$. (K 21·425.)
FIG. 2a.—*Reticularia barakarensis* sp. nov. Portion of surface of same specimen showing well-preserved ornamentation. × 6.
FIG. 3.—*Reticularia barakarensis* sp. nov. Pedicle-valve of a young individual × 2. (K 21·425.)
FIG. 4.—*Reticularia barakarensis* sp. nov. Portion of shell with well-preserved fimbriated lamellæ. × 6. (K 21·424.)
FIGS. 5, 5a.—*Reticularia barakarensis* sp. nov. Impressions of different parts of surface of one shell, showing variation in appearance of ornamentation. × 6. (K 21·424.)
FIG. 6.—*Reticularia barakarensis* sp. nov. Portion of surface of another shell showing well-preserved fimbriated lamellæ. × 6. (K 21·425.)
FIG. 7.—*Reticularia barakarensis* sp. nov. ? Impression of part of surface of another shell with indistinct concentric arrangement of spinules. × 6. (K 21·425.)
FIG. 8.—*Reticularia barakarensis* sp. nov. Pedicle-valve, showing dental plates. × $1\frac{1}{2}$. (K 21·424.)
FIG. 8a.—*Reticularia barakarensis* sp. nov. Posterior view of same specimen. × $1\frac{1}{2}$.
FIG. 9.—*Reticularia barakarensis* sp. nov. Brachial valve (uncrushed). × 2 (K 21·425.)
FIG. 10.—*Reticularia barakarensis* sp. nov. ? Internal cast of young pedicle-valve. × 2. (K 21·424.)
FIG. 11.—*Athyris* aff. *protea* Abich. Imperfect pedicle-valve. × 2. (K 21·425.)
FIG. 12.—*Pleurotomaria umariensis* sp. nov. × $2\frac{1}{2}$. (K 23·264.)
FIG. 13.—*Pleurotomaria umariensis* sp. nov. Short turbinate variety. × 6. (K 21·425.)
FIG. 14.—*Jonesina* ? sp. × 8. (K 21·425.)
FIG. 15.—*Palaeocypris* ? sp. × 8. (K 21·425.)
FIG. 16.—*Cytherella* ? sp. × 6. (K 21·425.)
FIG. 17.—*Rhombopora* sp. × 6. (K 21·425.)

PLATE 35.

FIG. 1.—*Productus rewahensis*, sp. nov. Pedicle-valve. × 1½. (K 23·263.)
FIG. 1a.— Ditto. Posterior view of same specimen. × 1½.
FIG. 2.— Ditto. Pedicle-valve. × 1½. (K 23·263.)
FIG. 3.— Ditto. Posterior view of another pedicle-valve. × 1½. (K 23·263.)
FIG. 4.—*Productus rewahensis*, sp. nov. Pedicle-valve. × 1½. (K 23·264.)
FIG. 5.— Ditto. Pedicle-valve. × 1½. (K 23·263.)
FIG. 6.— Ditto. Interior of brachial valve. × 1¼. (K 23·264.)
FIG. 7.—*Productus rewahensis*, sp. nov. Internal cast of pedicle-valve. × 1¼. (K 23·264.)
FIG. 8.—*Productus rewahensis* var. *coroides*. Pedicle-valve. × 1½. (K 23·261.)
FIG. 8a.— Ditto. Side view of same specimen. × 1½.
FIG. 9.—*Productus umariensis* var. *spinifera*. Pedicle-valve. × 1½. (K 23·263.)
FIG. 10.—Indet. brachiopod (genus uncertain). × 6. (K 23·261.)
FIG. 11.—*Pleurotomaria umariensis* sp. nov. × 3. (K 23·264.)
FIG. 12.— Ditto *ditto*. × 3. (K 23·264.)
FIG. 13.— Ditto *ditto*. × 2½. (K 23·264.)
FIG. 14.—Dermal tubercle of fish. Side view. × 2. (K 23·262.)
FIG 14a.— Ditto. Portion of surface. × 6.
FIG. 15.— Ditto. Side view of another specimen. × 2. (K 23·264.)
FIG. 16.—Dermal tubercle of fish. Side view of another specimen. × 2. (K 23·262.)
FIG. 16a.—Dermal tubercle of fish. Top view of same specimen. × 2.
FIG. 16b.— Ditto. Front view of same specimen. × 2.
FIG. 17.— Ditto. Side view of another specimen. × 2. (K 23·262.)
FIG. 17a.—Dermal tubercle of fish. Front view of same specimen. × 2.
FIG. 18.— Ditto. Side view of another specimen. × 2. (K 23·262.)
FIG. 18a.—Dermal tubercle of fish. Front view of same specimen. × 2.

PLATE 36.

FIG. 1.—*Spirifer narsarhensis*, sp. nov. Pedicle-valve. × 1½. (K 23·262.)
FIG. 1a.— Ditto. Interior of same specimen. × 1½.
FIG. 2.— Ditto Pedicle-valve. × 1½. (K 23·262.)
FIG. 3.— Ditto. Pedicle-valve. × 1½. (K 23·262.)
FIG. 4.— Ditto. Pedicle-valve. × 1½. (K 23·262.)
FIG. 5.— Ditto. var. Brachial valve. × 1½. (K 23·262.)
FIG. 6.— Ditto, var. *pauciplicata*. Brachial valve. × 2. (K 23·262.)
FIG. 7.—*Spirifer narsarhensis*, var. *pauciplicata*. Pedicle-valve. × 2. (K 23·262.
FIG. 8.—*Reticularia barakarensis*, sp. nov. Pedicle-valve. × 1½. (K 23·262.)

FIG. 8a.—*Reticularia baarkarensis*, sp. nov. Brachial valve of same specimen. × $1\frac{1}{2}$.

FIG. 9.—*Reticularia barakarensis*, sp. nov. Another brachial valve. × $1\frac{1}{2}$. (K 23·262.)

FIG. 10.—*Reticularia barakarensis*, sp. nov. Brachial valve with shell preserved. × $1\frac{1}{2}$. (K 23·262.)

FIG. 11.—*Reticularia barakarensis*, sp. nov. Pedicle-valve of young individual × $1\frac{1}{2}$. (K 23·262.)

FIG. 12.—*Reticularia barakarensis* var. *subplicata*. Pedicle-valve. × $\frac{1}{4}$. (K 23·262.)

FIG. 13.—*Reticularia barakarensis* var. *subplicata*. Pedicle-valve. × $1\frac{1}{4}$. (K 23·262.)

FIG. 14.—*Janeia* aff. *biarmica* (De Vern.). Right valve. × 5. (K 23·264.)

FIG. 15.—Crinoid stem. × $2\frac{1}{2}$. (K 23·262.)

FIG. 15a.— Ditto. articulating face of same specimen. × $2\frac{1}{2}$.

THE GEOLOGY OF THE UMARIA COALFIELD, REWAH STATE, CENTRAL INDIA. BY E. R. GEE, B.A. (CANTAB.), *Assistant Superintendent, Geological Survey of India.* (With Plates 37 to 39.)

INTRODUCTION.

THE completeness, so far as the coal-deposits were concerned, of the geological survey of the Umaria coalfield carried out by Mr. T. W. H. Hughes of the Geological Survey of India, in the early eighties,[1] rendered dormant the specialised attention of Indian geologists to this area, until in the year 1921, considerable scientific interest was aroused by the discovery by Mr. K. P. Sinor, Rewah State Geologist, of a marine fossil bed in these Lower Gondwana sediments.[2]

Following a visit by Dr. C. S. Fox to this coalfield, I was deputed during the month of June 1926 to make a geological resurvey of the area, to examine in detail the Lower Gondwana strata in which these marine fossils occur, and to add to the collection if possible. The additional forms which were collected have been described by Dr. Cowper Reed in an adjoining paper.

The attached geological map (Plate 39), represents the results of this resurvey. Comparing it with the one in Mr. Hughes' memoir, the main difference is seen to be in the distribution of the Supra-Barakar rocks in the western part of the area. Considering, however, the importance of the recent palæontological discovery, and bearing in mind the similarities and differences which the Gondwanas of this area exhibit when compared with their equivalents in Bengal and elsewhere, it seems worth while to record the Gondwana succession of this coalfield in greater detail than has previously been done.

Physical geography of the area.

The Umaria coalfield itself forms a relatively level cultivated tract, about 1,460 feet above sea-level. It opens out to the east and north-east, but is bounded on the west and south by thickly forested ridges which attain an altitude of about 1,800 feet. The

[1] *Mem. Geol. Surv. Ind.*, Vol. XXI, 1925.
[2] *Rec., Geol. Surv. Ind.*, Vol. LIV, 1922, p. 14, *Bull. No. 2, Geological Dept., Rewah State*, 'Rewah State Coalfields' (1923), pp. 1-22.

Katni-Bilaspur branch of the Bengal-Nagpur railway traverses the area in a general north-west to south-east direction, Umaria itself being 36 miles distant from Katni station. The strata of the southern part of the coalfield are to a great extent hidden by alluvium, but to the north-west of Umaria the more porous sandy Gondwanas crop out. The main line of drainage—the Umrar river—meanders across the coalfield in a general northerly direction, while a number of small tributaries traverse it in a north-easterly direction from the uplands to the west and south.

General geology and geological structure. The geological formations met with in the Umaria coalfield include :—

Alluvium.
Trap.
Gondwanas. { Supra-Barakars. Barakars. Talchirs.
Metamorphics.

There is, as is to be expected, a very close relationship between the main physical and the geological features of the area. The wooded uplands to the south of the coalfield represent the ancient metamorphic land-surface against which the Gondwanas were deposited. To the north-west the crystalline rocks again constitute the boundary of the field, but here the junction is a faulted one. The general dip of the strata being in a northerly direction, newer beds are met with as we traverse the coalfield from south to north. This simple structure has, however, been complicated as a result of folding which has thrown the beds into a sharp syncline close to the Narsarha fault and a more gentle anticline further south-east towards Umaria. Evidence will be given later that this faulting along the north-western edge of the field, accompanied by an inclination of the strata near the fault, commenced previous to the deposition of the Barakar strata, and continued more actively during the period of formation of the Supra-Barakars; with the result that these Supra-Barakar rocks, in the vicinity of the fault, overlap on to the lower Barakar horizons and finally on to the Talchirs also. This overlap increases in the upper Supra-Barakar rocks, so that, as the vertical displacements continued, these strata also were in places brought into faulted juxtaposition with the metamorphics.

DETAILS OF THE VARIOUS FORMATIONS.

The following is a description of these various formations in detail.

I.—THE METAMORPHICS.

The Metamorphics include a variety of types considerably foliated and penetrated by numerous quartz and pegmatite veins. Specimens, typical of the area, were commented on by Dr. Heron as being closely comparable to the gneisses of the Rajputana area. To the south of the coalfield these rocks include pink and grey felspathic gneisses and hornblendic types, associated around Karimati with bands rich in magnetite iron-ore. The foliation dips usually at a steep angle to the south and south-south-west. The continuous outcrop of these metamorphics passes along the edge of the jungle to the south of Koilari, but, in the village itself, an outcrop of white quartzite again occurs. It seems probable, therefore, that the gneisses would be met with at no great depth immediately below the alluvium in the intervening area to the south of Koilari village.

Immediately north-west of the Narsarha fault finely foliated micaceous schists and white quartzites predominate. Coarser textured felspathic gneisses come in further west, and include large pegmatite veins, in some cases rich in soda felspar, in others, rich in mica. The quartzites met with close to the fault, especially to the north-east of the railway, are usually much brecciated. The gneisses and schists dip almost vertically and strike in a north-east to south-west direction parallel to this faulted boundary of the coalfield.

II.—THE GONDWANAS.

Talchir sections along the south side of the Coalfield.

The Talchirs.—The most complete section of the Talchir rocks is seen in the north-easterly-flowing tributary of the Umrar river to the south of Bikatganj. The geological succession is as follows :—

(Yellow-brown fine textured soft sandstones.—Basal Barakars.)

Red and green stratified clays.

Conglomerate, of fairly well rounded boulders of gneiss and quartzite set in a dull-green clayey matrix.

Yellow and light green bedded clays and fine argillaceous sandstones including bands with a few rounded pebbles. The clays include at intervals narrow bands of calcareous light green mudstone up to 6 inches in thickness. The dip is to the north-north-east at about 12°.

Soft greenish felspathic grit with quartzite pebbles.
Green clays including boulders of gneiss and quartzite.

(Pink felspathic gneisses, dipping south at 60°).

In the main Umrar river all exposures of the Talchirs are hidden by alluvium until we approach the gneissic boundary to the south of Mahroi. At this point, within a short distance of the Metamorphics, yellow green Talchir conglomerates are seen to crop out in the river-bank.

In the tributary east of Chandwar the junction of the Talchirs with the gneisses is again fairly well defined. A greenish conglomerate crops out, separated from the Metamorphics by a narrow band of alluvium. With this boulder-bed yellow green argillaceous sandstones and clays are associated, but a short distance further north an east-to-west running fault appears to bring in more arenaceous types, together with a yellow-grey fine calcareous sandstone weathering in an irregular tufaceous manner. To the north and west of Chandwar village, however, the Gondwana strata are again obscured by dull green clayey alluvium so that the geological boundaries are very indefinite in this vicinity. No Talchir outcrops are seen until we reach the Narsarha *nala* to the east and south of Paunian. In the acute southern loop of this main stream, half a mile east-south-east of Paunian, yellow-green argillaceous sandstones and clays, including boulders of gneiss and quartzite, dip at about 20° to the north-north-east. These exposures are separated by a short stretch of sandy alluvium from the Supra-Barakar rocks observed in the same stream-course, a short distance to the north. The section is again obscured in places by alluvium, but, further west, red and green conglomeratic clays, considerably indurated, crop out against the main north-west fault in the tributary west of Paunian. The typical splintery clays of the Talchirs are not seen, though the strata noted closely resemble some of the beds met with in the section south of Bikatganj.

The Talchirs of the Narsarha railway cutting.

The next Talchir section to be described is that of the railway cutting of the Bengal-Nagpur line (*See* Plate No. 37). Here the Talchirs crop out over a distance measured horizontally, of about 52 yards. They are inclined at a fairly steep angle to the south-east, but close to the metamorphics the splintery nature of the clays renders the dip unobservable. Dull red and

green splintery clays, including occasional large boulders of gneiss and quartzite, probably of local origin, comprise the greater part of the Talchir group in this section. In the upper part of the section, about 45 yards from the metamorphics, these splintery clays give place to yellow sandy varieties showing definite stratification, and dipping south-east at 36°—38°. Resting on these beds with slight unconformity, are the gritty red clays with argillaceous limestone bands, which include the marine fossils, brachiopods and small gastropods. These latter beds comprise the base of the Barakars.

The Talchir-Metamorphic faulted boundary is almost vertical. Grey micaceous foliated schists are brought into contact with the Talchir clays and, though the boundary in this section shows no evidence of marked shattering, this is perhaps explicable by the fact that the beds on both sides of the fault are of a comparatively soft elastic nature; furthermore, the stratification of the Talchirs near the fault, owing to the fragmentary nature of the clays, is not observable. At other points along the line of the supposed fault, however, conclusive evidence, in the nature of intense crushing and silicification, can be seen. Continuing north-east, in the neighbourhood of this Metamorphic boundary, no exposures of the adjacent Gondwanas are observed until the first tributary crossing the fault in an east-south-easterly direction is reached; here, indurated Talchir conglomerates crop out. A better section is, however, seen further east in the tributary just west of the "C" of Chhatan. Here the rocks at the immediate boundary comprise much brecciated and silicified Talchir conglomerate, showing marked evidence of a faulted contact. These beds are well-exposed, dipping steeply to the south-east, adjoining the Metamorphics. A few yards downstream, the unaltered green Talchir clays, including boulders of gneiss and quartzite, crop out. Separated from these rock-exposures by a short stretch of alluvium, yellow-green clays and soft sandstones occur. These may be either of Talchir or of Lower Barakar type. In the tributary about half a mile south-east of the railway cutting silicified Talchir sandstones and conglomerates are exposed.

The rocks adjoining the north-western boundary-fault.

North of the village of Chhatan, alluvium again hides the older strata, but when we approach the Umrar river the Supra-Barakar beds, dipping steeply to the south-east, are brought against the crystallines. Further north, where the fault crosses the river,

definite Talchir conglomerates, silicified and considerably brecciated strongly indicative of a faulted junction, crop out against the gneisses. In the acute bend to the west of Banreri, although the actual junction is hidden by alluvium, yellow and green pebbly clays and sandstones come in about 30 feet to the east of the gneisses, dipping south-east at 10°. These sediments give place to grey massive sandstones in the tributary to the east.

The coal-bearing Barakar rocks.

The Barakars.—From an economic standpoint the most important area of Barakar rocks is to the north of the railway in the vicinity of Umaria. In this locality several coal-seams have been located in the middle and upper parts of the series; these are being worked by the Rewah State collieries. South of the railway, however, the lower Barakar strata crop out above the Talchir sediments of the tributary south of Bikatganj.

The lower Barakars near Bikatganj.

These rocks include a basal yellow-brown, fine textured, soft sandstone, resting, apparently conformably, on the uppermost Talchir shales and conglomerates. As we approach the junction of the two main tributaries massive grey sandstones, more typically Barakar in character, come in, with coarse grits and a thin pebble-bed in the upper part. Above these strata massive grey felspathic sandstones again crop out. Close to the junction with the Umrar river these sandstones include a 14-15 inch coal seam, with shales and fireclays above and below. The middle and upper beds of the Barakar series have been carefully described by Hughes (*op. cit*). They include mainly the typical massive grey sandstones with intercalated coal-seams and fireclays, but reddish and yellow sandstones are also included in this series. These beds crop out in the Umrar river to the north of Umaria village, but to the west of Lalpur and for some distance to the north no exposures are seen on account of alluvium. The upper strata of the series are well observed in the tributary flowing north to Oatsganj.

The Barakars of the Narsarha railway cutting.

From a purely geological point of view, by far the most interesting outcrop of the Barakars is seen in the Narsarha cutting of the railway, two miles north-east of Umaria railway station. It is here that the marine fossil horizon is exposed (*See* Plate 38). The section of these Barakar sediments is a comparatively narrow one, attaining only about 320 feet measured

along the railway line, for the strata are rapidly overlapped by the Supra-Barakar pebble-beds in the southern part of the cutting. The lowest beds, resting upon the uppermost yellow-brown sandy clays of the Talchirs, comprise argillaceous rocks of somewhat similar lithology to the Talchirs below; these strata, however, pass up quite gradually into sandy clays and sandstones of Barakar facies, whilst a slight, but definite unconformity appears to separate them from the Talchir rocks below.

Details of the marine fossil horizon.

There appears to be considerable lateral variation in detail in these marine fossil beds. The best section is observed in the western slope of the cutting, and it is this section which will be described. The lateral variation is exemplified in the two detailed sections tabulated below:

Measured sections of the marine fossil beds as exposed in the western slope of the Narsarha Cutting.

(About 15 feet above the railway line.)	(About 27 feet above the railway line.)
Soft yellow-grey sandstones with bands of yellow-green clays.	Soft yellow-grey sandstones with bands of yellow-green clays.
(A) 8 inches. Soft yellow sandstones, with small rounded pebbles and including a number of large brachiopods (*Productus*).	(A) 8 inches. Sandy yellow-brown layer with small quartzite pebbles and large brachiopods (*Productus*).
12 inches. Dull reddish and grey-green clays.	12 inches. Dull red and drab grey clays.
(B) 1½ inches. Yellow-brown soft sandy band with numerous large and small brachiopods (*Productus* and *Spirifer*).	(B) 1 inch. Thin sandy band with few brachiopods.
8 inches. Dull red and greenish clays.	9 inches. Red and green clays.
(C) 4-5 inches. Hard calcareous shell-bed including similar brachiopods.	(C) 2 inches. Hard calcareous brachiopod shell-band.
9-10 inches. Red and green gritty clays including brachiopods at the base.	2 inches. Dull red and grey-green clays.
4 inches. Red and grey gritty clays.	

Measured sections of the marine fossil beds as exposed in the western slope of the Narsarha Cutting—contd.

(About 15 feet above the railway line.)

5 inches. Hard grey calcareous gritty band with brachiopods at the base.

5 inches. Gritty clays.

1 inch. Calcareous grit band.

(D) 12 inches. Dull red and green gritty clays, including brachiopods and numerous small gastropods at the base.

1½ inches. Hard grey calcareous grit.

15 inches. Dull red and green clays with gneissic boulders included, and occasional brachiopods (*Productus*).

2-4 inches. Grey calcareous argillaceous band.

(About 27 feet above the railway line.)

1½ inches. Grey calcareous grit band.

2 inches. Gritty green clays.

1½ inches. Grey calcareous band.

2½ inches. Grey green gritty clays.

2 inches. Grey calcareous band.

2 feet. Dull grey-green clays with pebbles.

3 inches. Hard calcareous band.

(These lower strata continue to converge and die out up the slope.)

3 feet. Dull green clays with a hard calcareons band, and including gneissic pebbles; it thins out up the slope.

Yellow sandy Talchir clays.

A small dip-fault of a few inches throw intercepts these strata (*See* Plate 38).

Noting the general relationships of these Barakar sediments of the cutting, one sees that they include an uppermost brown earthy sandstone bed dipping S.15°E. at 30°, below which are soft yellow and grey argillaceous sandstones with bands of light green and grey clays inclined at 34°. A similar dip is noted in the uppermost fossil horizons which follow beneath. There was no evidence to suggest an unconformity between these lower Barakar sandstones and the marine fossil strata. The lithology indicates a gradual transition from the yellow argillaceous sandstones including the *Productus* ho rion (A) in its lower part, to the dull green and reddish clays in which the lower fossil zones are included. The strata, including the three upper fossil horizons (A) to (C), appear to continue with similar thickness and dip up and into the western side of the cutting, and are probably represented in slightly varied form in the fossil horizons of the eastern slopes. Below the (C)

horizon, however, the beds show considerable lateral variation in thickness and a peculiar slight unconformity on the Talchir strata below them. They thin out when traced up the western bank and exhibit a definite overlap of the upper fossil horizons on to the lower ones, and possibly on to the yellow sandy Talchir beds below (*See* Plate 38). In fact, these lower fossiliferous clays, with intervening harder, grey, calcareous, argillaceous bands, appear to occur in a definitely lenticular form, the lenticle closing near the edge as we go south-westwards, up and into the south-western slope of the cutting. Thinning out takes place of both the red and green gritty clays with fossils, and of the intercalated calcareous bands. It appears, therefore, that this lateral variation is neither the result of surface creep in the upper slopes, nor is it due to the squeezing out of the softer intercalated clays; the exposure described reaches not more than halfway up the side of the cutting and is cut well into the rock *in situ*. The section suggests a definite slight unconformity on the Talchir beds, the latter forming a slightly concave shelving base of deposition, which was filled up by the boulder-bearing clays and lowest marine beds, after which a slight rise in the relative sea-level resulted in the overlapping of the upper zones across the lower ones. Following this, a period of conformable deposition occurred with a gradual change of conditions, resulting in the shallow-water deposits of the lower Barakar sandstone stage.

Suggested conditions of deposition.

The difference between the Talchir-Barakar deposits of the railway cutting and of those sections along the southern unfaulted boundary of the field is doubtless explained by the varying conditions of deposition in the two localities. It is suggested that downward movement along the south-east side of the north-western boundary fault of the coalfield commenced previous to the formation of these Lower Barakar strata, so that the Upper Talchir rocks of that area formed a gradually shelving or locally undulating marine bed very suitable for the existence and accumulation of such marine organisms. This relative displacement, at the same time, caused the Upper Talchir rocks to be locally exposed to the erosive action of marine currents and so provided material of similar lithological character for the formation of the Lower Barakar fossil beds. At a slightly later date the conditions of deposition of the typical Lower Barakar sandstones, unfavourable to marine life, spread westwards, and

resulted in the extermination of this local colony, and the establishment of Lower Barakar conditions throughout the coalfield. At a later date, further downward movement along this line of faulting resulted, doubtless, in the rapid overlap of the Supra-Barakar beds.

Efforts to locate the fossil horizons in the stream sections near the boundary fault on either side of the cutting met with no success. The exposures are disappointing and might well explain the apparent absence of these fossil-beds; for although the indurated Talchir rocks were often seen against the Metamorphics of the fault-boundary, and the overlapping Supra-Barakars a short distance to the south-east, the strata of the intervening tract were invariably hidden by alluvium, so that no continuous section was observable. In addition it should be remembered that from the evidence of the sections in the Narsarha cutting, the strata including these marine fossils are of lenticular form, varying considerably when traced laterally. This suggests that the organisms existed in local colonies, possibly separated by areas where, owing to local factors, conditions were unfavourable for their existence. If such were the case, considering the very few complete sections of the rocks of the Lower Barakar stage met with in this coalfield, it is not surprising that no other fossiliferous locality was discovered.

The Supra-Barakars.—The Supra-Barakar strata include a lower series of grey, yellow and orange, soft, felspathic sandstones, medium to coarse-textured, alternating with thick brightly-tinted clays, usually red, purple, or light green in colour, together with an upper series of similar soft sandstones, including beds of well-rounded quartzite pebbles set in a soft sandy matrix.

The lower group of sandstones and clays apparently overlap the uppermost Barakar beds to the north of Umaria. In the vicinity of Loharganj these Supra-Barakar strata are brought into faulted juxtaposition with the Metamorphics, and are well-exposed, acutely folded, and striking parallel to the fault. They are well seen in the stream flowing in an east-north-east direction towards Oatsganj, where they dip at a fairly steep angle to the north and north-northwest. In the distributaries flowing south-east from the Metamorphics the dip is seen to change rapidly to the south-south-east, again at a steep angle. In these stream sections the upper sandstones and pebble-beds appear to rest upon the soft yellow sandstones —probably Barakar—which are separated by a

The Supra-Barakars of the Narsarha railway cutting.

short stretch of alluvium from the Talchir conglomerates of the fault face. The intervening lower Supra-Barakar beds—the soft sandstones and variegated clays—are apparently overlapped towards the fault. These pebble-beds and sandstones, exposed in the north-western limb of the syncline, continue to crop out south-westwards in the stream sections to within about 700 yards of the Narsarha cutting. In this intervening portion, however, alluvium obscures the strata. In the south-eastern part of the railway cutting exactly similar soft felspathic gritty sandstones and conglomerates are exposed resting directly on the Lower Barakar yellow sandstones which occur above the marine fossil-bearing beds. These sandstones and quartzite pebble-beds are of the same yellow and reddish tinges and include a badly exposed band of red clay at their base; they dip in a southerly direction at an angle of from 15° to 20°. From their lithology and from their mode of occurrence when compared with the above-mentioned sections to the north-east, there seems little doubt that these pebble-beds of the railway-cutting belong to the Supra-Barakar conglomerate horizon. There appeared to be no evidence of a fault separating these strata from the soft Barakar sandstones which occur further north along the cutting. The section is best explained on the supposition that relative movement along the boundary-fault was still in progress, and being accompanied by an inclination of the older sediments in the vicinity of the fault, these upper pebble-beds naturally overlapped the lower strata to within a short distance of the Talchirs. On the contrary, on the southern side of the coalfield where the faulting is absent, such intensive overlapping of the various Gondwana stages has not taken place. Occasional outcrops of red clays, largely obscured by dark clayey alluvium, occur in the stream-course just west of the railway between the Narsarha cutting and Umaria station. With them are associated yellow-grey hard calcareous sandstones weathering in an irregular tufaceous manner. To the south-west the soft pebbly sandstones and red clays are seen in the Paunian *nala* to be brought against the Metamorphics of the boundary-fault, the dip of these Supra-Barakar strata increasing to a fairly steep angle as the fault is approached. These sediments are separated by only a short stretch of alluvium from the conglomerates and clays of the Talchirs to the south. Again, to the north-east of the railway-cutting, where the fault approaches the Umrar river, these Supra-Barakar strata are brought against the faulted crystallines, the

crushed rocks near the boundary being considerably indurated, silicified, and quartz-veined, whilst a short distance south-east of the fault the beds are thrown into a sharp fold.

The line of hills running north-east of Banreri village is composed largely of massive sandstones and pebble-beds of the Supra-Barakars, associated with red ochreous clays. These strata are, apparently, cut off to the north-west by the continuation of the boundary fault.

III.—TRAP.

Trap occurrences.

No occurrence of trap-rock *in situ* is met with actually within the coalfield. To the south-east, however, a short distance east of Karimati, sills of basalt cap the isolated sandstone hillocks. These represent outliers of the extensive flows which cover the wooded uplands to the south.

IV.—ALLUVIUM.

A short distance south of the railway in the vicinity of the Umrar river dark-brown and black alluvium, including numerous well-rounded boulders of trap-rock, forms a thick covering over the older strata, and extends southwards to Mahroi. Dark clayey alluvium is again met with over a large portion of the area south-west of the railway between the Narsarha cutting and Umaria station, and forms a very fertile soil for cultivation.

LIST OF PLATES.

ON THE COMPOSITION AND NOMENCLATURE OF CHLOROPHÆITE AND PALAGONITE, AND ON THE CHLOROPHÆITE SERIES. BY L. LEIGH FERMOR, O.B.E., D.SC., A.R.S.M., F.A.S.B., F.G.S., *Officiating Director, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

In a recent paper Dr. M. A. Peacock [1] has given an account of the palagonitic tuffs of Iceland. In this paper he describes the macroscopic and microscopic appearances of both the sideromelan and palagonite of Von Waltershausen. In addition, analyses are given. The previously held view that the palagonite of Iceland is a hydrated form of sideromelan is confirmed, and the similarity of palagonite and chlorophæite, pointed out by the present writer,[2] is noted.

Dr. Peacock observes, however, that the actual process by which palagonite has been formed from the basalt glass, for which he uses the name sideromelan of Von Waltershausen, is different from the late magmatic changes to which various authors, myself included, have attributed the formation both of chlorophæite and of the related constituent of basaltic lava flows to which the term palagonite has been applied not only in India but elsewhere. Dr. Peacock recommends, therefore, that the use of the term palagonite to denote certain late magmatic hydrous materials in basalts and dolerites be discontinued; and he has had the courtesy to write to me to suggest that I should propose for this purpose some term instead of palagonite.

[1] *Trans. Roy. Soc. Edin.*, LV, pp. 51-76, (1926).
[2] *Rec. Geol. Surv. Ind.*, LVIII, pp. 140-141, (1925).

Before considering what term should be selected, it seems desirable to see whether we agree with Dr. Peacock in his suggestion that another term is necessary. The reasons for Dr. Peacock's suggestion may be summarised as follows :—(1) palagonite is the hydrogel of sideromelan and has been formed in some cases at low temperatures by submersion in water and in others as the result of hot-spring action, (2) chlorophæite and the palagonite, so-called, of the Indian basalts and similar rocks elsewhere, have been formed, in the view of the authors describing these rocks, as the result of late magmatic changes, and these changes have, in some cases, affected not only the interstitial glass of the original basalts, but also the augite, iron-ore, and even occasionally the labradorite felspar, the change being evidently in part one of replacement. In fact, Dr. Peacock wishes to restrict the term palagonite to 'the hydrogel of sideromelan which occurs only in fragmental basaltic ejecta'.

Now, it appears to be a sound principle that rocks or minerals should be named according to their composition and structure, and that in this process the views of an author concerning the origin of the rock or mineral should be suppressed as far as possible, so that subsequent possible changes of view should not necessitate changes of name. Two rocks or two minerals of diverse origin, but of similar composition and structure, should receive the same name. Taking the Archæan formations of India, for instance, a rock composed of interlocking quartz grains is correctly described as a quartzite whether it has been formed by the metamorphism of a pure quartz sandstone or by crushing, that is granulitisation, of vein quartz. Similarly, a banded metamorphic rock composed of felspar, quartz, and biotite is described as a biotite-gneiss whether it has resulted from the metamorphism of an original granite, or from the metamorphism of a shale. The geologist may express his views of the origin of the quartzite or of the gneiss by suitable descriptive adjectives ; but, primarily, the name should be selected on the basis of what the rock is now, and not on the basis of the geologist's view, which may be wrong, of the origin of that rock.

Coming now to the term under discussion we observe that Dr. Peacock bases his suggestion that different names are required for these two classes of products, (*a*) upon the suggested difference between the materials from which they have been produced and (*b*) upon the differences in the processes by which these materials

have been formed in the view of the geologists who have described them. It appears to me that, in accordance with the principles expressed in the preceding paragraph, even if these two differences can be sustained, different names will be applicable to the respective products only if they are substantially different chemically and physically. On the other hand, if they are similar chemically and physically, it does not matter whether the original materials from which they were formed, or the processes by which they were formed, were similar or different, one name should be applicable to both. However, it will be interesting first to examine briefly the two supposed differences referred to above.

Sideromelan is a name given by Von Waltershausen to the unaltered glassy material constituting the tuffs from which the palagonite of Iceland has been formed. A reference to page 57 of Dr. Peacock's paper shows, however, that the composition of this sideromelan is but slightly different from that of a normal basalt. Comparing this analysis with Washington's series of 11 analyses of Iceland basalts [1] it is seen at once that this analysis is very similar to that of other Iceland basalts (it is slightly on the low side in silica and potash). There seems, in fact, to be no special reason why the term sideromelan should be preserved at all. The general name for basalt glass is *tachylyte* and although in practice the majority of tachylytes may be, as Dr. Peacock points out, characteristically opaque, yet this cannot be regarded as universally applicable. In India many of the basalt dykes of Deccan Trap age have glassy margins; when this glassy substance is examined in thin sections under the microscope, it is found to be glassy clear except for scattered phenocrysts of fresh felspar and fresh olivine, as is described by Dr. Peacock in the case of his sideromelan. If these glasses should be termed sideromelan because of their transparency, then the term is no longer restricted to tuffs. On the other hand, if the term sideromelan be not used because the rock is not a tuff, then there is no alternative to the use of tachylyte, and at once we have an example of transparent unclouded tachylyte. It seems to me better to recognise that tachylyte is a general term applicable to all basalt glass, and to follow Penck [2] and Teall [3] in treating sideromelan as merely a variety of tachylyte.

[1] *Bull. Geol. Soc. Amer.*, XXXIII, p. 783. (1922).
[2] *Zeit. d. d. Geol. Gesellsch.*, XXXI, p. 522, (1879).
[3] 'British Petrography,' p. 137.

The other point of difference maintained by Dr. Peacock is one of conditions of formation, mainly differences of temperature. According to Dr. Peacock some Iceland palagonite has been formed by the action of cold sea-water under the pressure of the head of the overlying water and some has been formed by hot springs (the hot volcanic waters of Bunsen) at atmospheric pressures. In the case of the Indian basalts the 'palagonitisation' is supposed to have resulted from the attack of residual magmatic waters whilst the basalts were cooling through the range of temperature from 374°C (the critical temperature of water) down to at least 200°C. The difference does not appear to me to be one of kind, but merely one of degree, as is illustrated by Iceland, where we have the production of palagonite by both cold water and hot springs. In all these cases, the formation of the ultimate hydrated product has been accompanied by the relative removal of lime, alkalies, alumina, and silica, with relative increase in the amount of iron and magnesia, and with the addition of water. The process is similar and the question is whether the products are the same.

On page 66 of his paper, Dr. Peacock gives an analysis of palagonite-rock. It appears from the text that this rock contains :

	Per cent.
Palagonite [1]	76
Sideromelan	3
Chlorite	14
Zeolites	7
	100

Making rough allowances for the composition of the other materials, it may be deduced that the composition of the palagonite itself is approximately as follows :—

	Per cent.
SiO_2	35
TiO_2	2·5
Al_2O_3	8
Fe_2O_3	13
FeO	0
MgO	7·5
CaO	7
Na_2O	0
K_2O	0
H_2O	27
	100·0

[1] In the restricted sense adopted by Dr. Peacock.

It is now necessary to discuss the composition of chlorophæite, which in my paper on the Bhusawal basalts is shown to be closely related to the substances there designated palagonite.

II.—COMPOSITION OF CHLOROPHÆITE.

The available analyses of chlorophæite are collected in the following table, with the addition in the final column of the analysis of palagonite from Iceland deduced on page 414 :—

Locality.	Chlorophæite.				Palagonite.
	Scuir Mohr, Rum.[1]	Nagpur, India.[2]	Near Edinburgh.[3]	Giants' Causeway.[4]	Iceland.[5]
SiO_2 . .	36·00	35·15	32·95	35·99	35
Al_2O_3 . .	..	1·00	5·40	10·49	8
Fe_2O_3 . .	22·80	21·77	12·37	11·89	13
FeO . .	2·46	2·18	9·18	1·63	0
MnO . .	0·50	0·35	0·33	0·08	..
CaO . .	2·52	2·51	3·05	5·15	7
MgO . .	9·50	5·02	4·75	10·52	7·5
Na_2O . .	tr.	..	1·68	0·76	..
K_2O . .	tr.	..	0·36	0·34	..
H_2O+ . .	7·23 (100°+)	4·98 (110°+)	5·20 (105°+)	9·04 (100°+)	27 (H_2O+ and H_2O-)
H_2O- . .	19·23	27·44	23·90	14·16	
TiO_2 . .	..	..	0·62	..	2·5
Total . .	100·24	100·40	99·79	100·05	100·0
G	(2·02)	1·83—1·84	1·81 ±	2·278	..
Refractive index	..	1·486 ± ·001	1·498 ±	..	1·500

[1]Analyst Heddle : *Trans. R. Soc. Edinb.*, XXIX, p. 87 (1879).

[2] Analyst P. C. Roy : *Rec. Geol. Surv. Ind.*, LVIII, p. 127 (1925). Refractive index by W. A. K. Christie.

[3] Analyst W. H. Herdsman : *Min. Mag.*, XX, p. 438 (1925).

[4] Analyst Heddle : *L.c.*, p. 88.

[5] Calculated from analysis by W. H. & F. Herdsman : *Trans. R. Soc. Edinb.*, LV, p. 66 (1926).

The four analyses of chlorophæite have been arranged in order of increasing alumina. A comparison of the Scuir Mohr and Nagpur analyses reveals a striking similarity between these specimens from two widely separated localities. The only noteworthy difference is that the Scuir Mohr mineral contains about 4½ per cent. more MgO and 6 per cent. less total water. The suggestion is that non-aluminous chlorophæite is a definite mineral with a definite chemical composition. The two aluminous chlorophæites form another pair,

though not so closely related, between which the main differences are 5 per cent. more alumina and 6 per cent. more magnesia in the Irish mineral, and 7½ per cent. less ferrous oxide and 6 per cent. less total water, than in the Edinburgh specimen. As a pair the aluminous chlorophæites are distinguished from the non-aluminous chlorophæites by their high alumina and the presence of a small but definite quantity of alkalies, in which soda predominates over potash. If one recalls the direction of change involved in the formation of chlorophæite in a basalt one may suggest that the aluminous chlorophæites are examples in which the removal of alkalies and alumina has not been pushed to a finish. The close similarity between the specific gravity and refractive indices of the Nagpur and Edinburgh specimens shows, however, that the resultant products are physically very closely allied.

On comparing the analysis of Iceland palagonite with those of chlorophæite, it is seen that it also must be regarded as an aluminous chlorophæite. In composition it is very close to the chlorophæite from the Giants' Causeway. The only marked difference is the absence of alkalies. This is due in part only to the fact that in deducing this composition from the analysis of the palagonite-rock the alkalies in the original analysis were allocated to zeolites; for the original analysis shows only 0·35 per cent. of total alkalies. The chemical similarity is in consonance with the almost identical refractive indices of the Iceland palagonite and the aluminous chlorophæite of Edinburgh. It seems very difficult therefore to treat the Iceland palagonite as a different mineral from chlorophæite.

The above analyses may be summarised as follows :—

——	Non-aluminous chlorophæite.	Aluminous chlorophæite.	Iceland palagonite.
SiO_2	35·15—36·00	32·95—35·99	35
R_2O_3	22·77—22·80	17·77—22·38	21
RO	10·06—14·98	17·31—17·38	14·5
R_2O	tr.	2·04— 1·10	..
H_2O	32·42—26·46	29·10—23·20	27
TiO_2	....	0·62	2·5
Refractive Index	1·486 (Nagpur)	1·498 (Edinburgh)	1·500 (Iceland)

Since these analyses when thus studied appear to agree so closely in a general way, it becomes interesting to examine whether they conform to any general chemical formula.

In the following table the five analyses have been reduced to molecular terms with the SiO_2 shown as 20:—

——	Scuir Mohr.	Nagpur.	Edinburgh.	Giants' Causeway.	Iceland.
SiO_2 (+TiO_2) .	20·00	20·00	20·00	20·00	20·00
R_2O_3 . .	4·78	5·01	5·06	5·93	5·19
FeO, MnO, CaO.	2·90 } 10·80	2·75 } 7·02	6·75	3·88	4·07 } 10·17
MgO . .	7·90	4·27	4·25 } 12·11	8·44 } 12·85	6·10
Alkalies . .	..	..	1·11	0·53	..
H_2O+ . .	13·46 } 49·27	9·49 } 61·81	10·36 } 58·31	16·78 } 42·14	.. } 48·83
H_2O— . .	35·81	52·32	47·95	25·36	..

A study of these molecular proportions shows that in the Nagpur analysis the molecular ratios approach closest to the whole numbers. The formula for the Nagpur mineral may be given as follows:—

$$9\tfrac{1}{2}H_2O.7RO.5R_2O_3.20SiO_2+52\tfrac{1}{4}H_2O.$$

This analysis happens also to be that showing the smallest molecular proportion of RO, and therefore will serve as a useful datum line. Bringing the R_2O_3 in each case to 5 by making an adjustment between the Fe_2O_3 and FeO, the 5 analyses correspond to the following molecular formulæ:—

Nagpur	$9\frac{1}{2}H_2O.7RO.5R_2O_3.20SiO_2+52\frac{1}{4}H_2O.$
Edinburgh . . .	$10\frac{1}{4}H_2O.11RO.1R_2O.5R_2O;.20SiO_2+48H_2O.$
Scuir Mohr . . .	$13\frac{1}{2}H_2O.10\frac{1}{4}RO.5R_2O_3.20SiO_2+35\frac{3}{4}H_2O.$
Iceland	$13\frac{1}{2}H_2O.10\frac{1}{2}RO.5R_2O_3.20SiO_3+35\frac{1}{2}H_2O.$
Giants' Causeway . .	$16\frac{3}{4}H_2O.14\frac{1}{4}RO.\frac{1}{2}R_2O.5R_2O_3.20SiO_2+25\frac{1}{4}H_2O.$

For the purposes of this paper and brevity of expression I propose to refer to the water driven off up to 100° to 110°C (different analysts use different temperatures) as *non-molecular water* and that driven off above this temperature as *molecular water.* A study of these formulæ shows that quite closely for every addition of one unit of 'molecular water' there is a decrease of four units of 'non-molecular water'. In the Iceland case, the water has been arbitrarily distributed in the proportions contained in the nearest parallel, the Scuir Mohr analysis.

A comparison of the formulæ allotted to the two extremes of this series—the Nagpur and Giants' Causeway minerals—suggests

the following general formula for the chlorophæites, R_2O when present being regarded as RO :—

$$2\tfrac{1}{2}H_2O.5R_2O_3.20SiO_2+n(RO.H_2O)+(80-4n)H_2O.$$

The first term is suggested by the fact that in both extremes of the series the difference between combined water and RO is $2\frac{1}{2}$; and the final term of $(80-4n)\ H_2O$ by the relationship between combined and additional water already noted.

The values for the above formula with $n=7$, 8, 11, & 14, respectively, are shown in the following table :—

Value of n	——	Compare formulæ on p. 417 for :—	Errors.
7	$9\frac{1}{2}H_2O.7RO.5R_2O_3 20SiO_2+52H_2O$	Nagpur .	$\frac{1}{4}H_2O$.
8	$10\frac{1}{2}H_2O.8RO.5R_2O_3.20SiO_2+48H_2O$	Edinburgh	$\frac{1}{4}H_2O,3RO,1R_2O$.
11	$13\frac{1}{2}H_2O.11RO.5R_2O_3.20SiO_2+36H_2O$	{ Scuir Mohr	$\frac{3}{4}RO,\frac{1}{4}H_2O$.
		{ Iceland .	$\frac{1}{2}RO,\frac{1}{2}H_2O$.
14	$16\frac{1}{2}H_2O.14RO.5R_2O_3.25SiO_2+24H_2O$	Giants' Causeway.	$\frac{1}{4}H_2O,\frac{1}{4}RO,\frac{1}{2}R_2O,1\frac{1}{4}H_2O$.

The fourth column shows the departures from these ideal formulæ of the actual formulæ referred to in column 3.

The only formula empirically determined that disagrees at all seriously with the above is that of the Edinburgh specimen, which shows 3RO and $1R_2O$ in excess. In both the Edinburgh and Giants' Causeway analyses, the alkalies are in excess of the formula, and it is perhaps doubtful if they enter therein. But obviously there is no basis for discussion of this point or of the meaning of the slight departures in the amounts of RO and H_2O shown in the other analyses. They may all lie within the limits of experimental error.

The closeness with which these five analyses, as also an analysis of neotocite (see page 427), conform to the general formula may be judged from fig. 1. The line AB represents the ratio of 'non-molecular' water to 'molecular' water for values of n from 0 to 20. The spots represent the actual water ratios for the six analyses. The thinner line CD represents the number of units of RO (with R_2O) for the same range of n from 0 to 20. The crosses show the actual values of RO for the six analyses. The only value that falls seriously out of place is that of RO for the Edinburgh chlorophæite. The value of the refractive index is shown where known. The progressive increase with increase of n is illustrated.

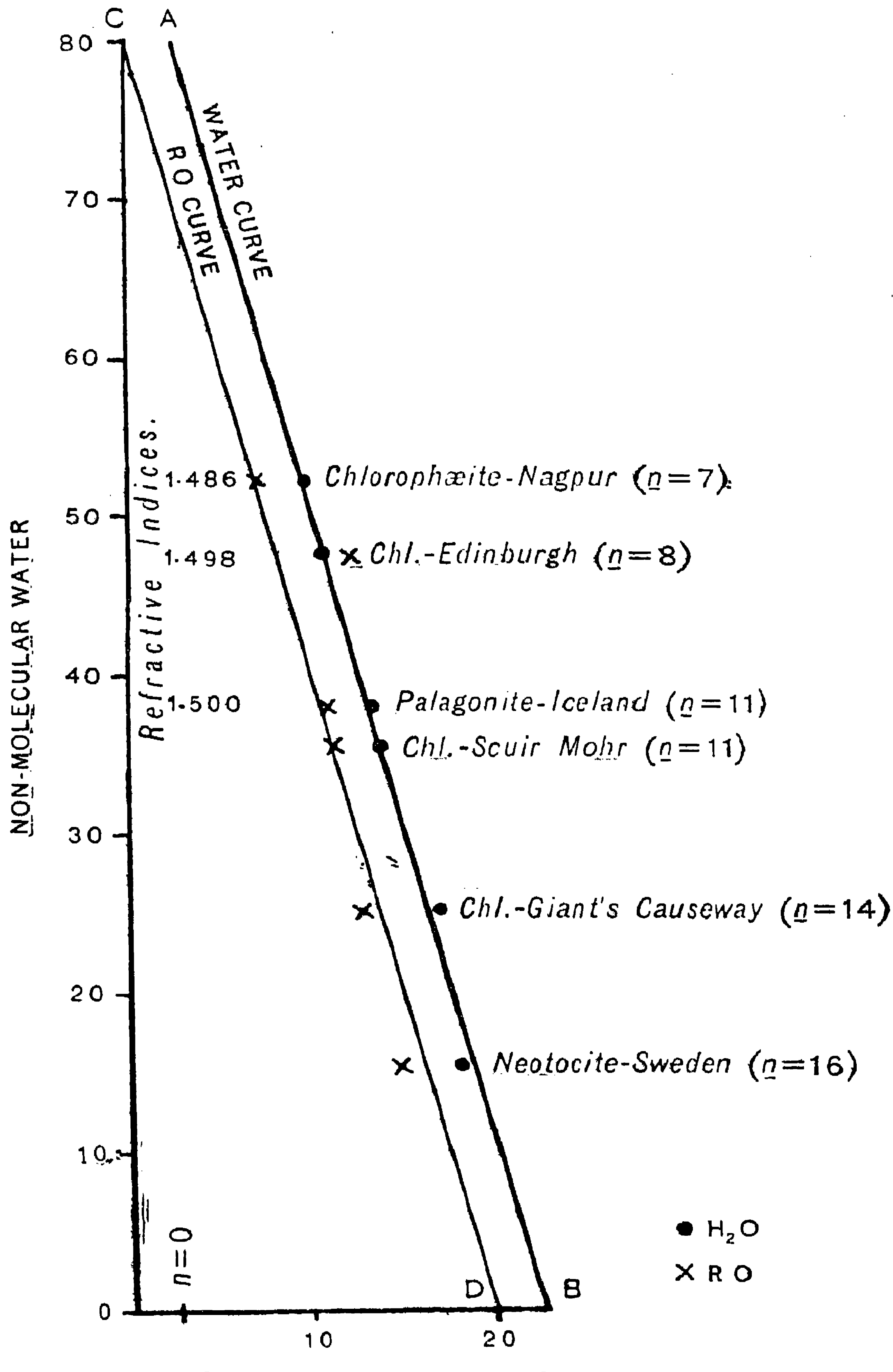


Fig. 1—Distribution of water in minerals of the chlorophæite series.

III.—THE USE OF THE TERM PALAGONITE.

From the preceding section it will be seen that it is difficult to treat the palagonite (*i.e.*, the gel-portion of the palagonite-rock) of Iceland as a different substance from chlorophæite. In petrographical literature the term 'palagonite' seems, however, to have received an application more comprehensive than to a substance with the characters of the palagonite of Iceland. In my paper on the 'Basaltic Lavas in Bhusawal,' I devoted several pages [1] to a discussion of the characters, composition and formation of palagonite and chlorophæite. The following quotation from page 133 may be given here :—

Palagonite in general.

'From the foregoing notes we see that under palagonite have been comprised at least two distinct substances. Treated generally, palagonite may perhaps be regarded as a hydrous glassy substance of variable composition formed partly by hydration of the primary glass and partly at the expense of augite (? again largely hydration) and iron-ore, and with much more difficulty at the expense of felspar (? by replacement). In colour it ranges through orange and brown to brownish green and bright green, and the material of all colours may become 'devitrified' and anisotropic in spherulites and concentric-radiate layers, with in all cases a positive elongation to the fibres. The clear orange and brown varieties, both isotropic and anisotropic, constitute chlorophæite, whilst the anisotropic green form is probably indentical with delessite or celadonite. It is exceedingly difficult to distinguish these two latter minerals one from another when in fine aggregates, but if one may assume the green mineral of the palagonite to be delessite, then the difference between orange palagonite (chlorophæite) and green palagonite (delessite) is very simple. A reference to the analyses given on page 136 will show at once that in most respects these two minerals are chemically very closely allied: the chief difference is that in chlorophæite the iron is mainly in the ferric condition whilst in delessite it is mainly in the ferrous condition. In addition, whilst delessite contains alumina as an essential constituent, the chlorophæite of the original locality is practically devoid of alumina. The chlorophæite of Giants' Causeway, however, yielded 10 per cent. of Al_2O_3. Finally, chlorophæite is more highly hydrous. It appears therefore legitimate to deduce that the formation of one or other of these two minerals is largely a function of degree of oxidation at the time of alteration. As both delessite (30 per cent.) and chlorophæite (36 per cent.) contain a considerably smaller percentage of silica than any of the original substances, primary glass (about 50 per cent.), pyroxene (about 55 per cent.) and labradorite (about 55 per cent.)—except iron-ore, their formation as a secondary product involves the separation of silica. This may, of course, be either removed in solution to be deposited in geodes and vesicles, or it might crystallise out as an additional complementary mineral with

Chemical difference between orange palagonite (chlorophæite) and green palagonite (delessite).

[1] *Rec. Geol. Surv. Ind.*, LVIII, pp. 125-135.

the palagonite. In the case of the green palagonite, where the Al_2O_3 is retained, the surplus silica has often appeared as the enclosed spherulites of chalcedony noticed above. But in the case of chlorophæite, as the Al_2O_3 of the original minerals is not always retained, the destination of this constituent appears also to require explanation. The chabazite supplies the obvious answer, for it explains the destination of both surplus Al_2O_3 and SiO_2, which may be assumed to have taken over such alkalies as were available. From this it should follow that chlorophæite is lower in alkalies than delessite. Alkalies cannot, however, be regarded as an essential constituent of either mineral and the published analyses suggest no marked difference in this respect. If therefore the green mineral be delessite it seems necessary to assume that its formation has involved the removal of alkalies in solution. Both chlorophæite and delessite are low in lime: in the former case the destination of this constituent, at least in part, is the accompanying chabazite, but in the formation of delessite lime must also have been removed in solution.'

In this paper it is shown that no distinction can be drawn between chlorophæite and orange or brown palagonite and if the term palagonite is to be restricted to the brown and orange varieties, then it is unnecessary as a mineral term, because the term chlorophæite has priority; but in the form of the name of a process, namely *palagonitisation*, it would still find use. If, however, the extended use of the term palagonite be retained, in accordance with which certain green substances also come under this term, then we are giving to the term palagonite a more comprehensive meaning, and, in this form, it will be of more use to science than if restricted to identity with chlorophæite. A study of Penck's elaborate paper 'Ueber Palagonit und Basalttuffe' [1] shows also that in spite of the use of the term *Palagonitfels* by Von Waltershausen the substances from Palagonia, Sicily, Iceland, and elsewhere, to which the term palagonite was originally applied were impure substances, namely rocks, *e.g.* many of the materials analysed by Bunsen[2]. And Dana [3] lists palagonite as—

'A basaltic tufa consisting chiefly of glass lapilli and the products of their alteration. It formerly passed as a mineral species, but properly belongs to petrography.'

It seems clear, therefore, that the term palagonite was originally applied to a less pure substance than that for which the term chlorophæite was proposed. It seems, therefore, that palagonite should be treated rather as a rock name whilst chlorophæite should be treated as the name of a gel-mineral. In this comprehensive sense

[1] *L.c.*, p. 567. 'Es existirt kein Mineral Palagonit'.
[2] *Pogg. Annalen*, LXXXIII, pp. 221-229, (1851).
[3] 'System of Mineralogy', p. 1043, (1911).

palagonite includes hydrated basaltic glass with, in some cases, products of replacement of minerals contained in, or associated with, basaltic glass. Palagonitisation is the process by which these hydrated products are formed. The products of palagonitisation may be either orange, brown, or green. If orange or brown, the substance is chlorophæite; if green, it is probably delessite, but this point has not yet been proved by analytical work. The analysis of palagonite used in these pages for comparison with analyses of chlorophæite is really an analysis of palagonite after removal of the other constituents, which are really a part of the palagonite, i the latter be treated as a rock.

IV.—THE CHLOROPHÆITE SERIES.

The discovery that even a general formula can be applied to a series of specimens of an apparent colloid substance obtained from several diverse localities indicates that chlorophæite cannot be treated as an indefinite mixture, but must be regarded as a definite mineral, the varieties of which have a range of composition conforming to a general formula.

Once the existence is admitted of a series of substances conforming to a general formula, it becomes a matter of curiosity to ascertain whether there are any other minerals either colloid or crystalline that conform to this general formula. To determine this point involves in the first place searching for hydrated minerals in which the ratio $R_2O_3 : SiO_2 = 1 : 4$, *i.e.*, $5 : 20$. It is obvious from inspection of the general formula that any compound with this ratio and with RO from 1 to 20 can be assigned to this series, if the amounts of molecular and non-molecular water be not taken into account. The following is a list of such minerals:—

Value of *n*.	Name of mineral.	G.	Refractive index.	H_2O divergence from series formula.
0	Montmorillonite . .	..	1·49—1·51 (1·56)	—48
	Chloropal . . .	..	..	..
2½	Nontronite . . .	2·50	1·588, 1·590, 1·645	—50
3	Nontronite . . .	..	..	—40
5	Phillipsite . . .	2·2	1·48, 1·51, 1·57	—45
	Gismondite . . .	2·27	1·539	—45
	Laumontite . . .	2·3	1·524	—47½
	Chabazite . . .	2·1	1·478, 1·480, 1·485	—37½
	Gmelinite . . .	2·1, 2·17	1·464, 1·470, 1·481	—37½
	Analcite . . .	2·25	1·487	—57½
	Glauconite . . .	2·2—2·8	1·688	—56
7	Chlorophæite . .	1·83—1·84	1·486	+ ¼
	Graminite . . .	1·87 (at 100°C.)	..	—31
7½	Stilpnomelane . .	2·85	1·595, 1·685	—50
8	Chlorophæite . .	1·81	1·498	— ¼
11	Chlorophæite . .	2·02	..	— ¼
	Palagonite . . .	..	1·500	— ½
	Minguetite . . .	2·86	..	—40
12	Bardolite . . .	2·47	..	—14
14	Chlorophæite . .	2·278	..	+ 1¼
16	Neotocite . . .	2·6	1·47, 1·54	+½
22½	Biotite. . . .	2·7—3·1	1·57—1·60	—12½

The figures in the final column indicate the divergence between the total amount of water present and the total amount required for a mineral conforming to the general formula of the chlorophæite series for the values of *n* shown in the first column. In the case of the zeolites the water divergence is calculated from the formulæ as given by Dana, but for the other minerals the divergence is calculated from actual analyses, the analyses used being collected in the following table, in which also two of the chlorophæite analyses are included in order to show the position of this mineral with reference to the others:—

Value of *n*	0	1	0	3	5	5	7	7	7½	11	12	14	16	23½
Mineral	$R_2O_3 = Al_2O_3$.	Montmorillonite	$R_2O_3 = Fe_2O_3$.	Nontronite.	Chabazite.	Glauconite.	Chlorophæite.	Graminite.	Stilpnomelane.	Minguetite.	Bardolite.	Chlorophæite.	Neotocite.	Anomite (Biotite.)
Locality		Montmorillon, France.[1]		Nontron, France.[2]	Nidda, Hesse.[3]	Lewes, Sussex.[4]	Nagpur.	Menzenberg, Germany.[5]	North, Wales.[6]	Minguet, France.[7]	Bardo, Poland.[8]	Giant's, Causeway.[9]	Gestrikland, Sweden.[10]	Lake Baikal.[11]
SiO_2 .	37·82	49·40	34·56	44·0	46·35	48·12	35·15	38·39	48·74	43·65	38·36	35·99	34·88	40·00
Al_2O_3 .	15·68	19·70	..	3·6	20·52	9·16	1·00	6·87	6·36	5·22	5·54	10·49	1·57	17·28
Fe_2O_3 .	..	0·80	22·89	29·0	..	19·10	21·77	25·46	22·47	18·80	16·59	11·89	18·58	0·72
FeO .	..	..	..	..	..	3·47	2·18	2·80	15·74	19·00	4·60	1·63	2·88	4·88
MnO .	..	..	..	..	..	..	0·35	0·67	0·50	..	..	0·08	22·67	..
CaO .	..	1·50	..	..	10·83	0·76	1·51	0·56	0·53	0·94	0·73	5·15	..	..
MgO .	..	0·27	..	2·1	..	2·36	5·02	0·75	1·43	3·22	9·41	10·52	2·50	23·91
K_2O .	..	1·50	..	..	0·21	7·08	..	1·14	0·75	3·00	4·67	0·34	..	8·57
Na_2O .	..	Tr.	..	..	..	0·22	..	..	..	0·66	0·46	0·76	..	1·47
H_2O+ .	1·41	15·12	1·29	18·7* (80°)		5·28 (105°)	4·98		6·36		7·10 (100°)	9·04	9·30	1·37
H_2O- .	45·08	10·55	41·26	..	22·09	4·78	27·44	23·36	2·59	6·00	12·40	14·16	8·07	..
F . .	..	..	..	1·2 (Clay).	..	..	..	..	..	..	..	..	..	1·57
		98·84	..	98·6	100·00	100·33	100·40	100·00	100·47	100·49	99·89	100·05	99·95	99·77

* Takes up about 12% more H_2O when immersed.
[1] Dana, p. 690, Analysis No. 1.
[2] Dana, p. 701 Analysis, No. 2.
[3] Dana, p. 591· Analysis, No. 1.
[4] Hallimond, *Min. Mag.* XIX, p. 331, Analysis, No. 12.
[5] Dana, p. 701, Analysis, No. 7.
[6] Hallimond, *Min. Mag.*, XX, p. 194, Analysis No. 1.
[7] Lacroix, *Bull. Soc. Franc. Min.*, XXXIII, p. 272.
[8] Morozewicz, *Bull. Soc. Franc. Min.*, XLVII, p. 52.
[9] Dana, p. 662, Analysis No. 2.
[10] Dana, p. 704, Analysis No. 4.
[11] Dana, p. 630, Analysis No. 1.

With the exception of the group of zeolites corresponding to $n=5$, and biotite, which, with $n=22\frac{1}{2}$, is just outside the series, the whole of these minerals occur in nature as fibrous, scaly or amorphous minerals, almost invariably in circumstances that show that they have been formed by the alteration of pre-existing minerals, in the presence of abundance of water. From the list on page 423 it will be seen, however, that the only other mineral that actually carries the correct total amount of water required for the chlorophæite series is neotocite (analysis 4 of Dana), and as the distribution into molecular and non-molecular water is also correct, neotocite, as represented by this analysis, may be regarded as a *mangan-chlorophæite*. In addition, glauconite and bardolite have the correct molecular water, but a deficit of non-molecular water.

When I started this search for additional minerals that might be referred to the chlorophæite series, I thought it possible that montmorillonite and chloropal (of which nontronite is treated as a variety by Dana) might prove to be the end members with $n=0$ and $R_2O_3=Al_2O_3$ and Fe_2O_3 respectively. The result is to show that montmorillonite and chloropal contain much too small a quantity of water to be referred to the chlorophæite series, but it may be suggested that each of these minerals at some stage of its formation, which probably was accompanied by progressive dehydration, may have conformed to the series formula.

In the course of consideration of the minerals given in the list on page 423 notes on each were prepared and the formulæ calculated and arranged in accordance with the general formula of the chlorophæite series. But it is considered that it will be of interest to print here only the notes on montmorillonite, chloropal with its variety nontronite, and neotocite.

Montmorillonite ($n=0$, 1).

The formula for $n=0$ is—

$$2\tfrac{1}{2}H_2O.5R_2O_3.20SiO_2+80H_2O.$$

The formula given by Dana is—

$$H_2Al_2Si_4O_{12}+n\text{aq. Le Chatelier.}$$

But the water is much less than $80H_2O$, as is shown by the figures in the table on page 424.

The analysis from Dana (by Salvetat) there quoted corresponds to—

$$20\tfrac{1}{2}H_2O.RO.5Al_2O_3.20SiO_2+14\tfrac{1}{4}H_2O.$$

The formula $n=1$ requires $(3\tfrac{1}{2}+76)H_2O$.
The formula adopted by H. Leitmeier [1] is—

$$Al_2O_3.4SiO_2.6H_2O.$$

Montmorillonite is found in abundance in the Central Provinces of India in the joint planes of certain manganese-ore deposits, *e.g.*, Kachi Dhana and Kandri. A specimen from Kachi Dhana gave on analysis figures close to those of the original mineral from Montmorillon, the total water being 26·76 per cent. ($37\tfrac{3}{4}H_2O$ against $34\tfrac{3}{4}H_2O$).

Chloropal. ($n=0$).

Whilst montmorillonite might be regarded as related to the end member of the series with $n=0$ and $R_2O_3=Al_2O_3$, chloropal might perhaps be regarded as related to the end member with $n=0$ and $R_2O_3=Fe_2O_3$. Dana gives the formula of chloropal doubtfully as $H_6Fe_2Si_3O_{12}+2H_2O$. If, however, it belongs to the chlorophæite series the formula should be $2\tfrac{1}{2}H_2O.5Fe_2O_3.20SiO_2+80H_2O$. The compositions required by these two formulæ are as follows :—

—	Dana.	$n=0$.
H_2O	20·9	42·55
Fe_2O_3	37·2	22·89
SiO_2	41·9	34·56

A few of the analyses given in Dana have the ratio $Fe_2O_3 : SiO_2$ approximating to the figures required by Dana's formula, but the majority are closer to the ratio 1 : 4. Usually there are small quantities of protoxides present so that $n=2$ or 3, as in nontronite :

Nontronite ($n=2\tfrac{1}{2}$ to 3).

This mineral is listed by Dana as a variety of chloropal, and is treated by Larsen [2] as identical with chloropal. Analysis 2 of

[1] *Zeitsch. Kryst.*, LV, p. 356, (1915).
[2] *Bull.* No. 679, *U. S. Geol. Surv.*, p. 286, (1921).

Dana has $Fe_2O_3 : SiO_2$ almost exactly $=1:4$; but taking Al_2O_3 into account the ratio is $1:3{\cdot}4$. Treating a portion of the Fe_2O_3 as $2FeO$, however, the analysis corresponds to :—

$$5\tfrac{1}{2}H_2O.3RO.5R_2O_3.20SiO + 22\tfrac{1}{4}H_2O.$$

The last term should be $68H_2O$ for $n=3$. Larsen gives the formula of nontronite as :—

$$(Ca,Mg)O.2Fe_2O_3.8SiO_2.7 \pm H_2O.$$

This is equivalent to :—

$$5H_2O.2\tfrac{1}{2}RO.5R_2O_3.20SiO_2 + 12\tfrac{1}{2}H_2O.$$

This corresponds with $n=2\tfrac{1}{2}$, except that the last term should be $70H_2O$.

Neotocite ($n=16$).

No formula is given for this mineral by Dana, who describes it as a hydrated silicate of manganese and iron, but of very doubtful composition. The proportion of sesquioxides is very variable, and in three analyses a high proportion of Mn_2O_3 is indicated. One analysis (No. 4) corresponds with the following formula :—

$$18H_2O.14\tfrac{3}{4}RO.5R_2O_3.20SiO_2 + 15\tfrac{1}{2}H_2O.$$

$n=16$ requires—

$$18\tfrac{1}{2}H_2O.16RO.5R_2O_3.20SiO_2 + 16H_2O.$$

This mineral, therefore, may be regarded as belonging to the chlorophæite series, even the degree of hydration and distribution of water being correct. If this analysis be correct, then neotocite may be regarded as a *mangan-chlorophæite* with MnO in place of MgO, etc., and with less water owing to its position in the series. The specific gravity (2·94) of neotocite is considerably higher than that of chlorophæite (1·81 to 2·28), but the refractive indices are closely similar :—

Neotocite (Larsen)	1·47 —1·54
Chlorophæite[1]	1·486—1·500

Larsen (*L.c.*, p. 115) remarks that the name neotocite should be confined to the amorphous mineral that has approximately the composition of bementite ($MnO.SiO_2.nH_2O$). If, however, as the

[1] The refractive index of the chlorophæite of Bhusawal ranges up to a figure slightly above that of Canada Balsam, *i.e.*, to over 1·544. *L.c.*, pp. 131, 151.

analyses show, neotocite contains considerable amounts of sesquioxides, then the foregoing treatment seems more suitable.

Summarising the above we may say that chlorophæite, palagonite, and neotocite, have the correct molecular and non-molecular water to be assigned to the series represented by the formula :—

$$2\tfrac{1}{2}RO.5R_2O_3.20SiO_2+n(RO,H_2O)+(80-4n)H_2O.$$

These minerals are all secondary colloid minerals, formed as the result of hydration of pre-existing minerals, and possessing refractive indices ranging from 1·47 to 1·54.

In addition, glauconite and bardolite correspond with the series formula except for a deficit of non-molecular water.

In nontronite and graminite (both varieties of chloropal) the molecular and non-molecular water have not been determined separately, except that nontronite may absorb water up to a total of 30 per cent. which is reduced to 18·7 per cent. at 80°C.[1] All that one can say safely of these two minerals is that there is a deficit of total water.

In montmorillonite, although the total water is too small, yet the combined water is too high for the formula.

This leaves only the zeolites, stilpnomelane, minguetite and biotite, which are definitely crystalline minerals. Although zeolites lose their water gradually on heating yet their maximum water is well below that required by the formula. Perhaps it may be suggested, however, that should they ever be found in colloid form they might carry water approximating to the formula.

It may be suspected from their mode of occurrence and microscopic appearance that did they occur in crystal form most members of this 1 : 4 series would prove to be micaceous in structure.

V.—SUMMARY.

1. Chlorophæite is a gel-mineral of variable composition, but the variations take place within the limits of a general formula, which is :—

$$2\tfrac{1}{2}H_2O.5R_2O_3.20SiO_2+n(RO.H_2O)+(80-4n)H_2O.$$

2. Four analyses of chlorophæite from Nagpur, Edinburgh, Scuir Mohr, and the Giant's Causeway, respectively, correspond to expressions of this formula with n=7, 8, 11 and 14.

[1] Berthier, *An. Ch. Phys.*, XXXVI, p. 24, (1827).

3. In so far as the data are available the specific gravity and refractive indices increase with the value of n.

4. The gel-mineral of the Iceland palagonite-rock described by Dr. Peacock is deduced to have a composition that brings it into the chlorophæite series with $n=11$. The refractive index of this palagonite falls into the correct place.

5. The term chlorophæite (Macculloch, 1825) has priority over palagonite (Von Waltershausen, 1846).

6. It is deduced, therefore, that the term palagonite should not be employed as a mineral-name and that the practice of Penck and Dana should be followed in accordance with which palagonite is regarded as a rock. When the rock contains no extraneous substances then palagonite equals chlorophæite-rock.

7. The basalt-glass known as sideromelan, from which some palagonite has been formed by modification and hydration, should be regarded as only a variety of tachylyte.

8. Used to describe certain secondary substances, but without the precision of a mineral name the term palagonite has been extended to comprise two varieties (1) orange and brown, and (2) green. The orange and brown palagonite when clarified from other substances is identical with chlorophæite. The green variety has not been studied but may prove, when free from other substances, to be identical with or related to delessite.

9. It is recommended that the term palagonitisation should be used to designate the process of hydration with accompanying chemical composition by which palagonite of both kinds is formed.

10. A consideration of analyses and properties of other minerals shows that at least one analysis of neotocite conforms to the chlorophæite general formula ($n=16$). This mineral may be regarded as a mangan-chlorophæite.

11. In addition to chlorophæite, palagonite and neotocite, which all have the correct distribution of 'molecular' and 'non-molecular' water to be referred to the chlorophæite general formula, there are several other minerals that conform to the series, except that the water content is deficient. These minerals range from montmorillonite and perhaps chloropal with ($n=0$) at one end of the series, through certain zeolites, glauconite, chlorophæite and various micaceous minerals to biotite at the other end ($n=22\frac{1}{2}$). The tendency is for all the hydrous minerals, excepting the zeolites,

with a ratio of $R_2O_3 : SiO_2 = 1 : 4$ to be, when not amorphous, either fibrous or micaceous. The majority of them are secondary minerals.

12. An examination of the general formula of chlorophæite shows that for every increase of one unit of 'molecular' water (water driven off above 100°—110°C), there is a decrease of four units of 'non-molecular' water (water driven off below 110°C). No explanation of this curious fact is offered, and it will be interesting to see whether future work on the chlorophæite series supports this relationship as expressed in the general formula.

MISCELLANEOUS NOTES.

Barytes from the Anantapur district, Madras.

Barytes occurs in the reserved forest near Nerijamupalle (14°32′30″ 78°1′) in the Anantapur district of the Madras Presidency. It occurs as veins in Vaimpalli slates and limestones which form part of the Papaghni series of the Cuddapah system. The outcrop of the largest vein is from 3 to 11 feet wide and it has been followed for more than half a mile along its strike, N. 110° E.; three other veins crop out close to the above vein, two of which strike respectively N. 125° E. and N. 110° E.

Another outcrop occurs in the Daditota reserved forest, 1½ miles north of the chief Nerijamupalle vein, and this also bears N. 110° E.

A representative set of specimens has been collected from both localities (M. 940 A.—Q. and M. 941 A.—D.). The average specific gravity of the Nerijamupalle barytes is approximately 4·4 and the colour, though generally white, varies to light green and a faint pink. A microscopic section (17574) of the vein material bordering the main vein (36/46) shows an argillaceous limestone with barytes, calcite, a little quartz and some chalcopyrite.

A. L. COULSON.

A. K. DEY.

Barytes in Orchha State.

According to Mr. M. K. Ray, Consulting Geologist, barytes has recently been found within the limits of the village of Khura (now called Surajpura; 24° 43′ 30″ : 79° 10′ 30″), which is 2 miles south-south-east of Deorda and forty miles from the nearest railway station, Man Ranipur (Great Indian Peninsular Railway).

The barytes occurs west of the village by the side of a hill called Chakrada. Mr. Ray, who has examined the deposit, states it is associated with about equal proportions of quartz in a vein in Bundelkhand gneiss and is also found in the adjoining rock. A little copper pyrites occurs with the barytes, but, as far as Mr. Ray could make out from a surface examination, there is insufficient copper ore for the vein to be worked as a supply of copper ore. No lead ore was found.

The vein strikes approximately N.W.-S.E. and it can be traced for about a quarter of a mile. This direction is that of the general strike of the basic rocks intruding the crystallines, but the usual strike of the quartz

veins is from N.N.E.-S.S.W. to N.-S. A little prospecting work has exposed a width of about eight feet of vein without reaching the walls. The estimated cost of transport to Man Ranipur is between Rs. 10 and Rs. 15 per ton.

The barytes found upon the surface is mostly brownish-white in colour, but the quality improves even at a depth of but two to three feet. A specimen (M. 949) was found to have a specific gravity of 4·395.

A. L. COULSON.

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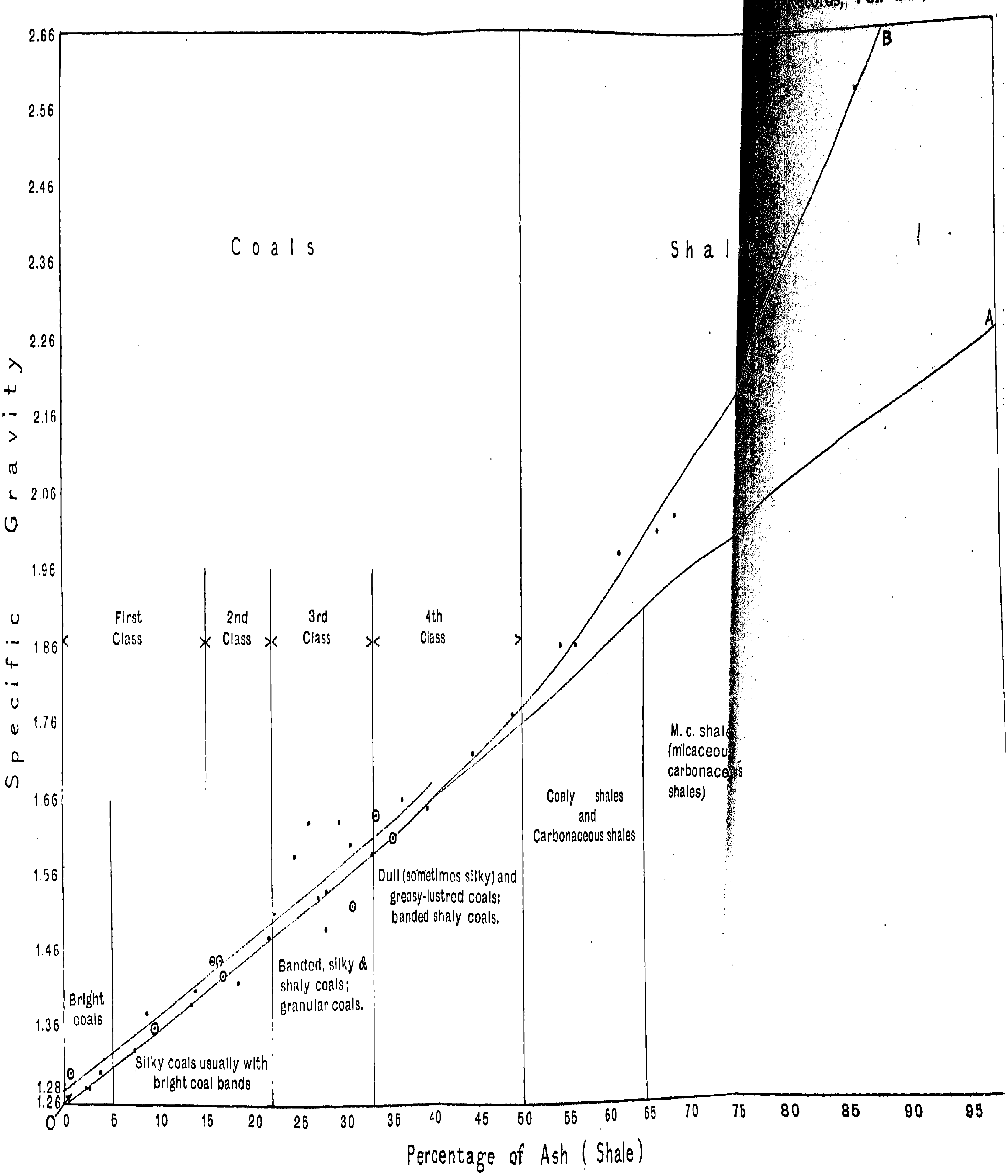

Coals
Shales
First Class
2nd Class
3rd Class
4th Class
Bright coals
Silky coals usually with bright coal bands
Banded, silky & shaly coals; granular coals.
Dull (sometimes silky) and greasy-lustred coals; banded shaly coals.
Coaly shales and Carbonaceous shales
M. c. shales (micaceous carbonaceous shales)
A
B
Specific Gravity
Percentage of Ash (Shale)
2.66
2.56
2.46
2.36
2.26
2.16
2.06
1.96
1.86
1.76
1.66
1.56
1.46
1.36
1.28
1.26
O
0
5
10
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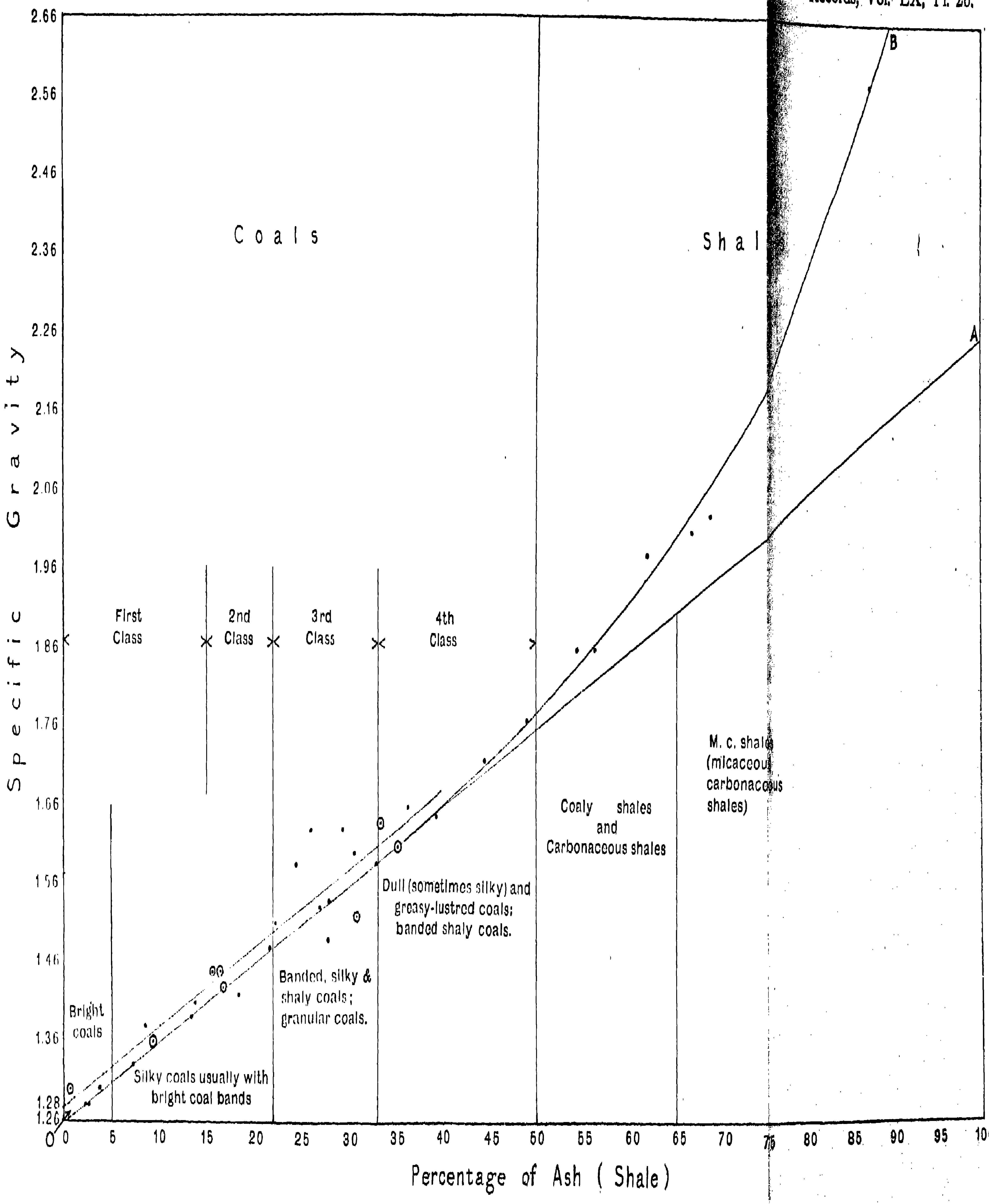
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1.28
1.26
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0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

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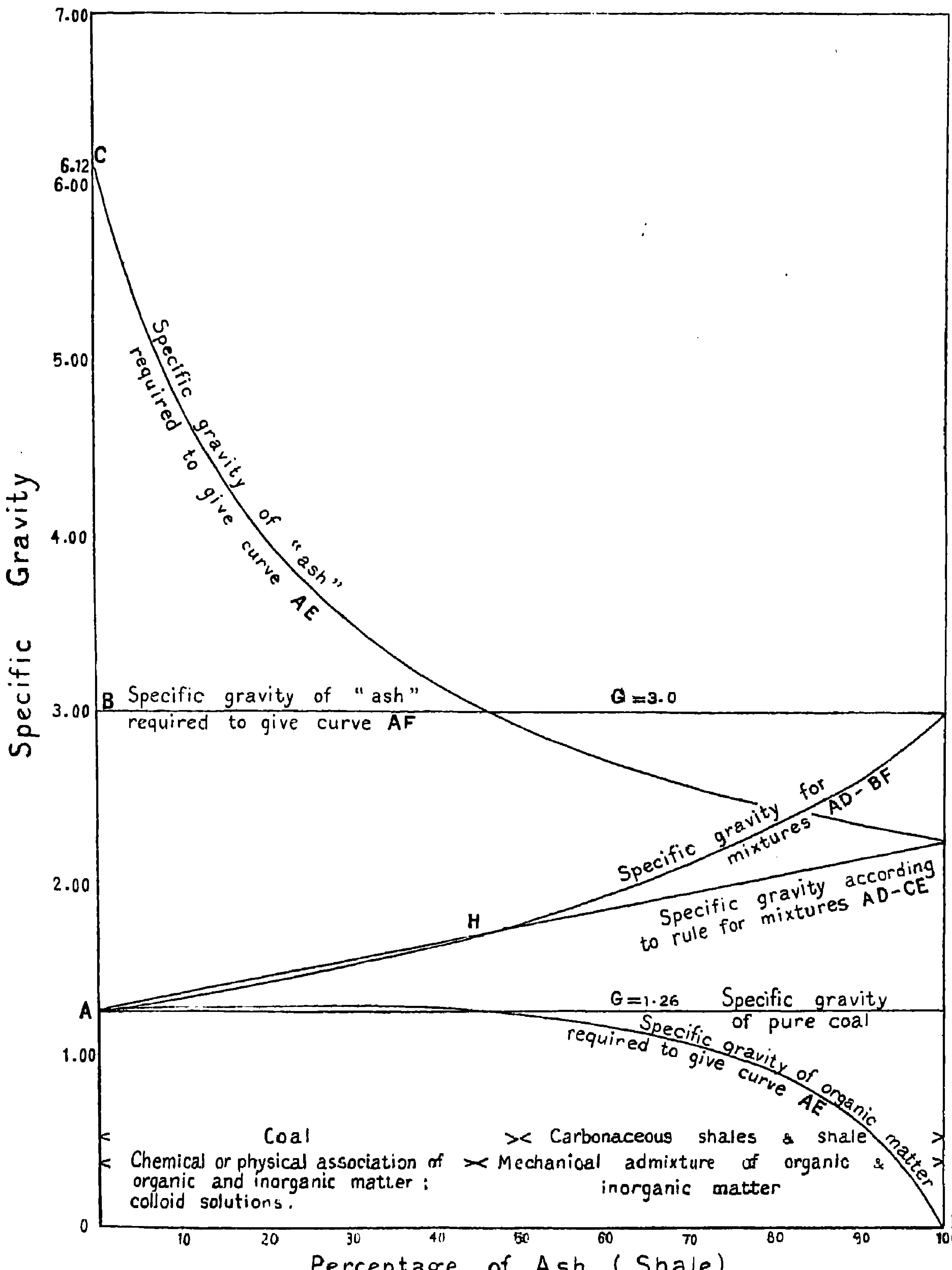
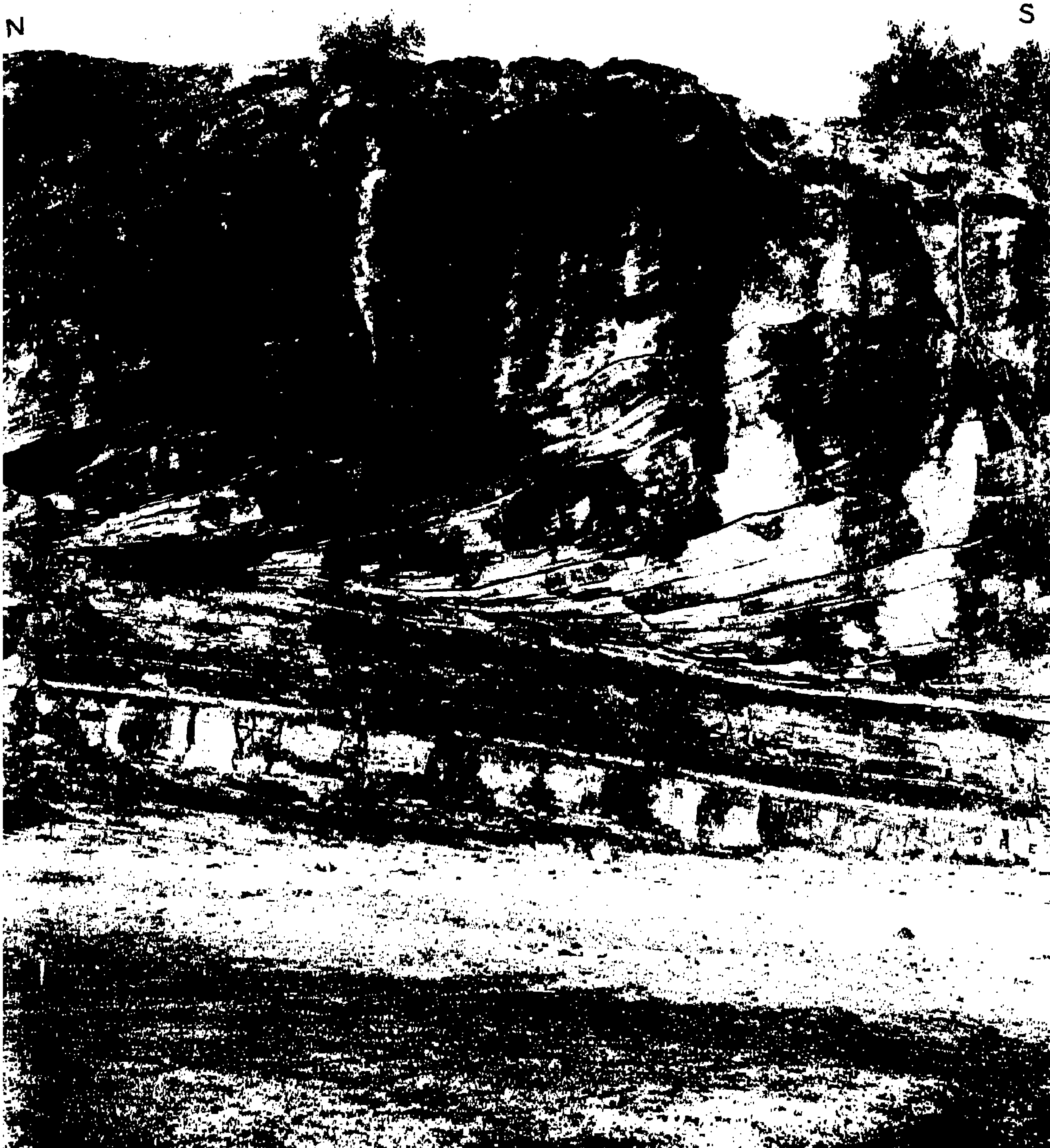


FIG. 1. PANCHET-RANIGANJ UNCONFORMITY IN STREAM NEAR JUNUT VILLAGE, RANIGANJ COAL-FIELD.

A. K. Banerjee, Photos. G. S. I. Calcutta.

FIG. 2. BARAKAR SANDSTONES IN A QUARRY, AT BEGUNIA NEAR BARAKAR RAILWAY STATION.



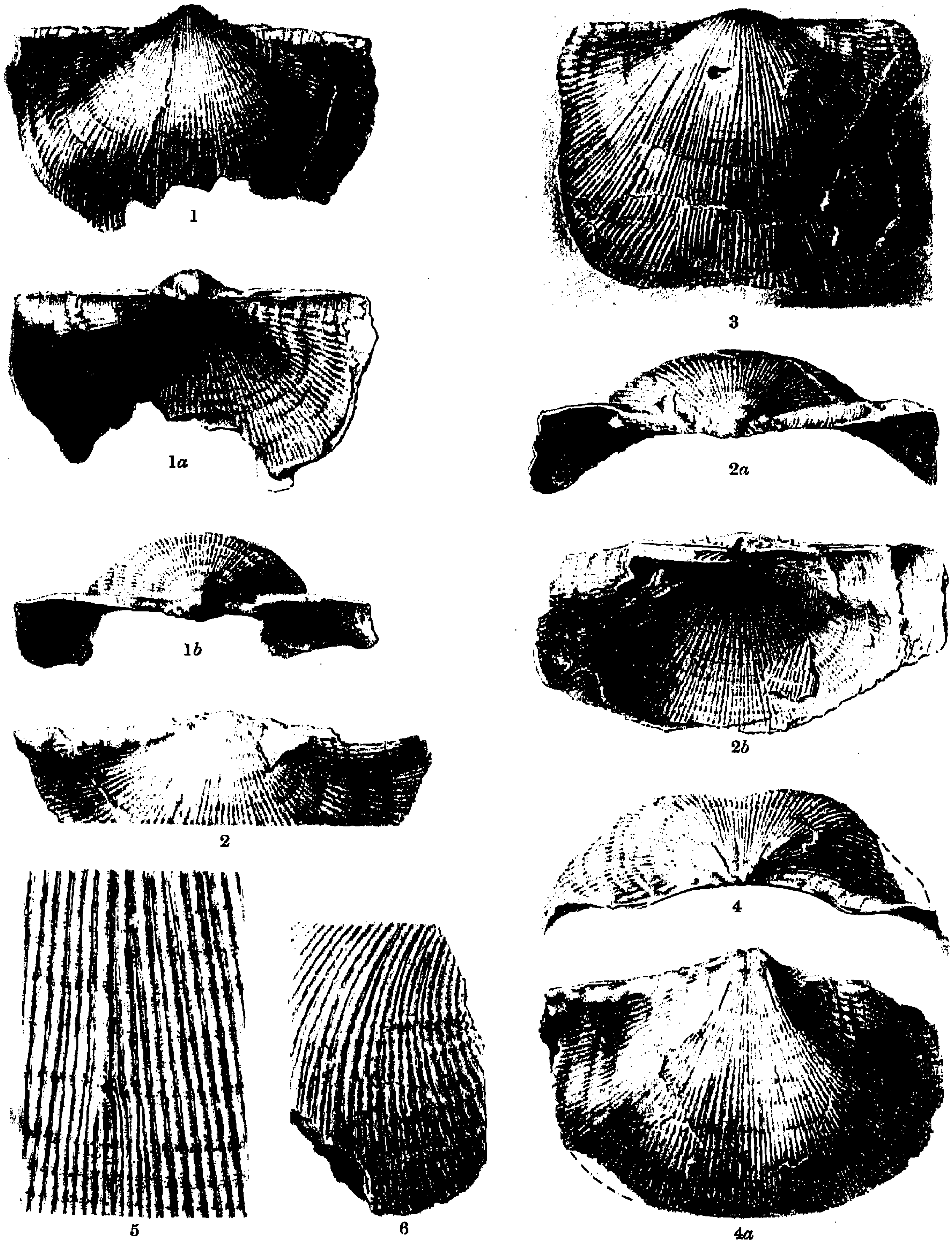
C. S. Fox, Photo. *G. S. I. Calcutta.*

FALSE-BEDDED BARAKAR SANDSTONES, AT CHANCH, RANIGANJ COAL-FIELD.

FIG. 1. FOSSIL TREE FROM KUMARPUR RAILWAY CUTTING, showing rings of growth.

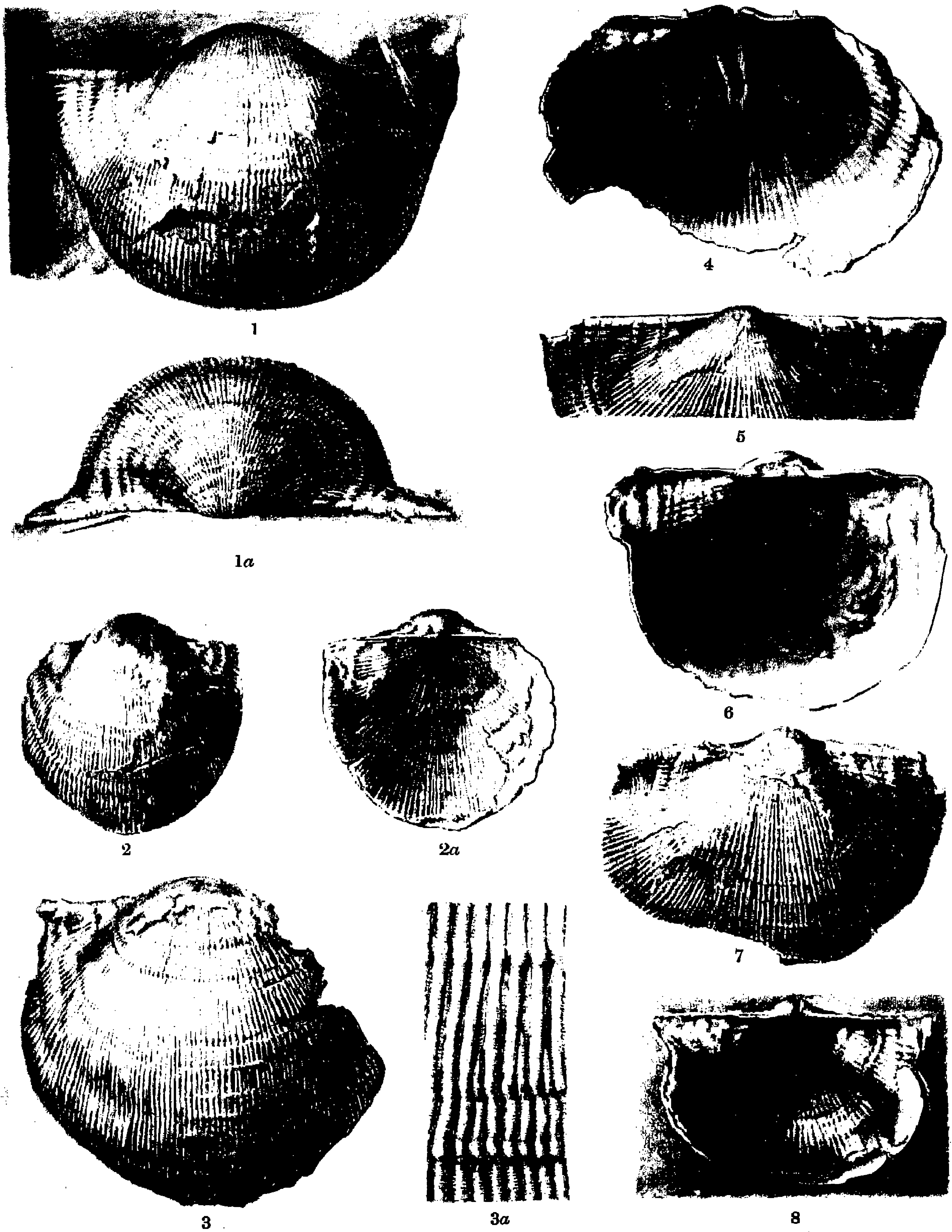
C. S. Fox, Photos. G. S. I. Calcutta.

FIG. 2. FOSSIL TREE IN KUMARPUR RAILWAY CUTTING.



E. T. Talbot, del.

PERMO-CARBONIFEROUS FOSSILS FROM UMARIA.



E. T. Talbot, del.

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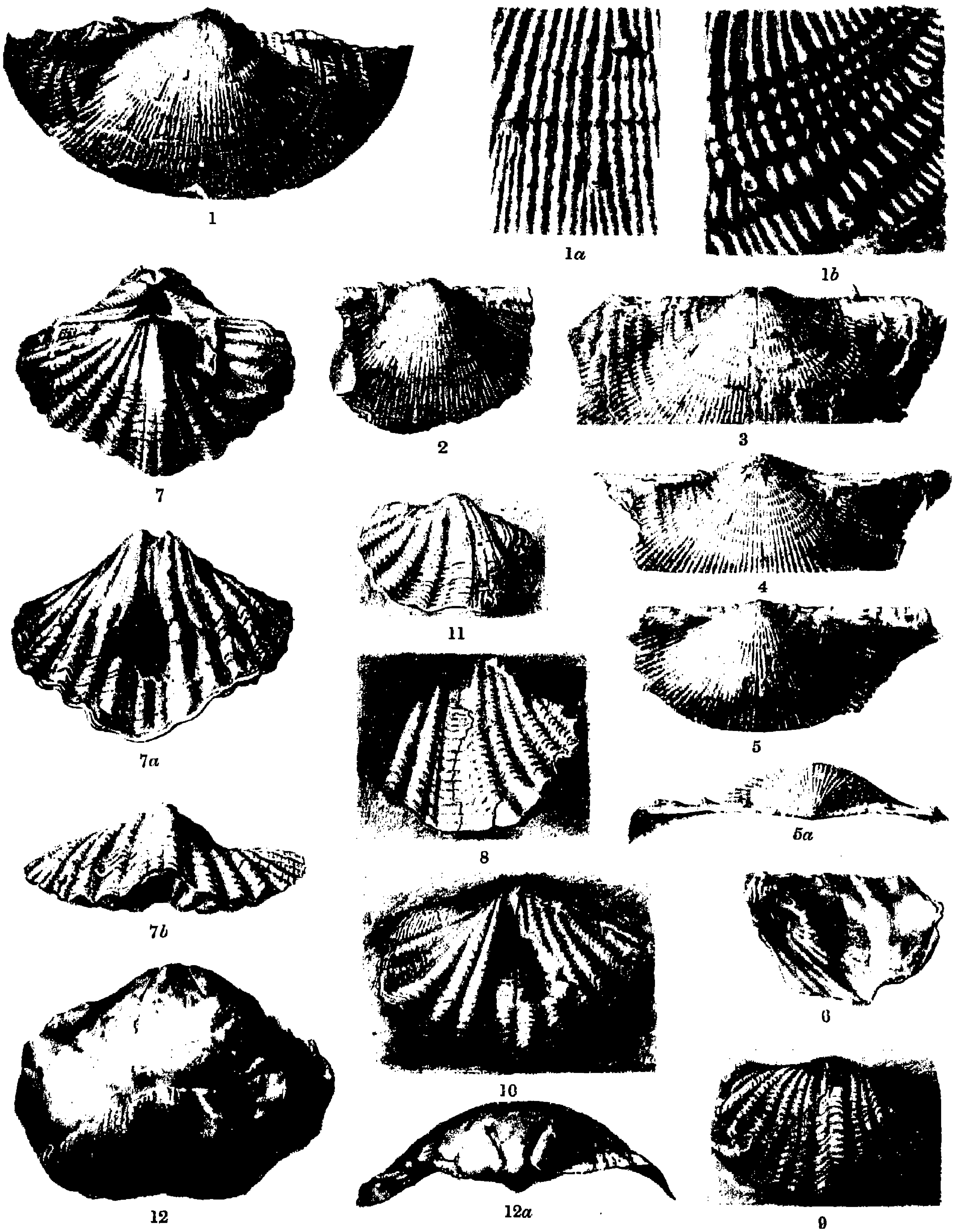

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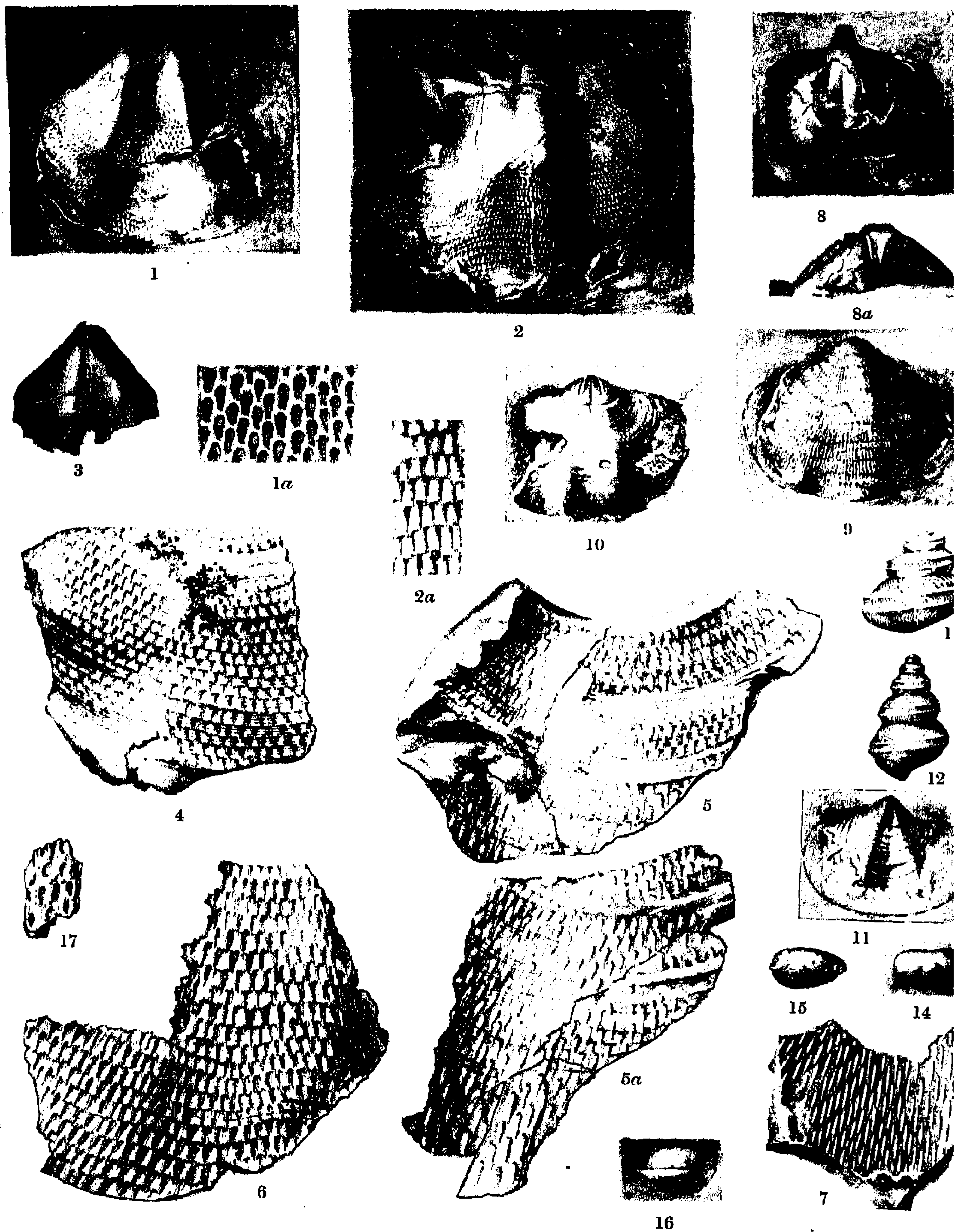

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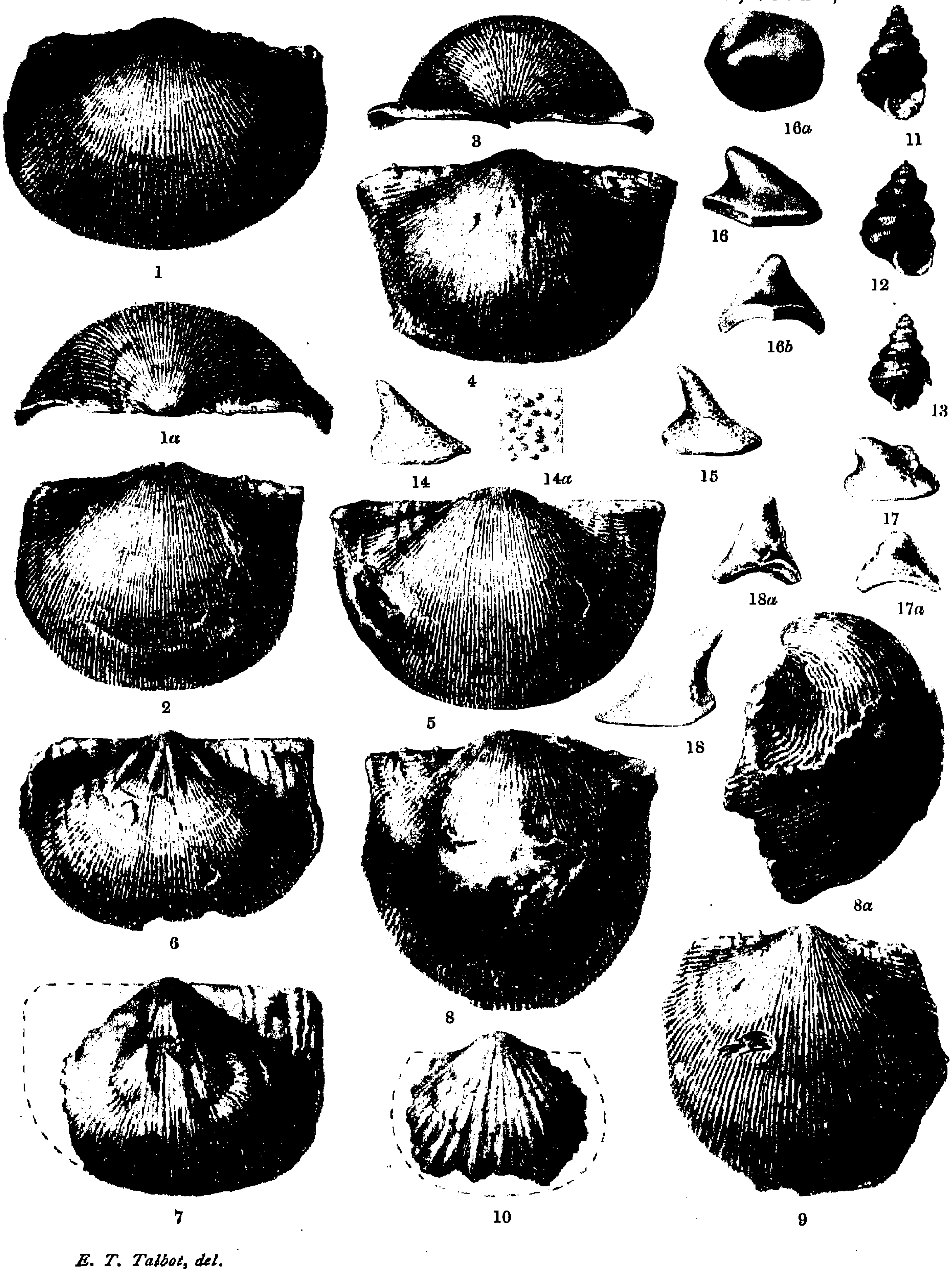
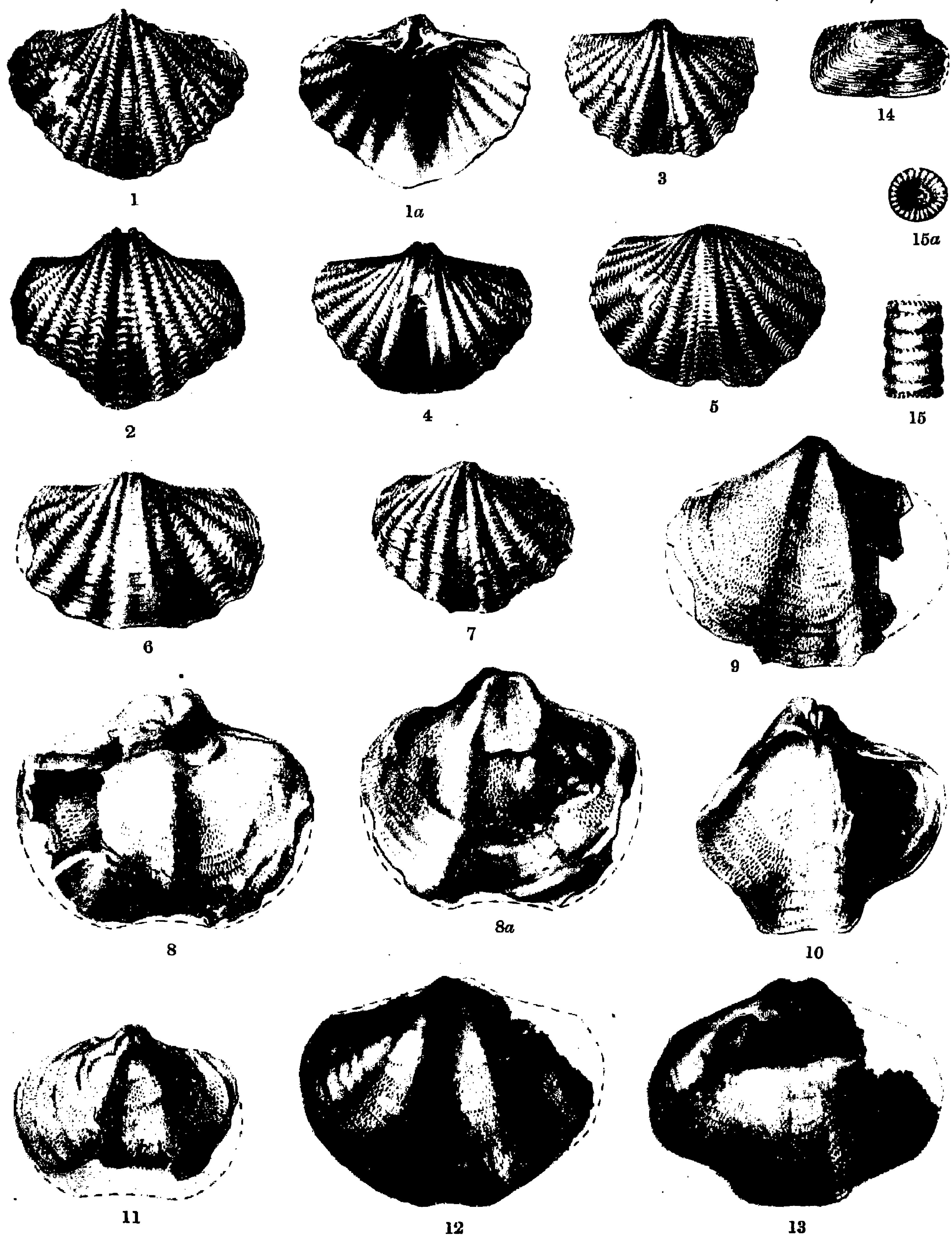


E. T. Talbot, del.

PERMO-CARBONIFEROUS FOSSILS FROM UMARIA.

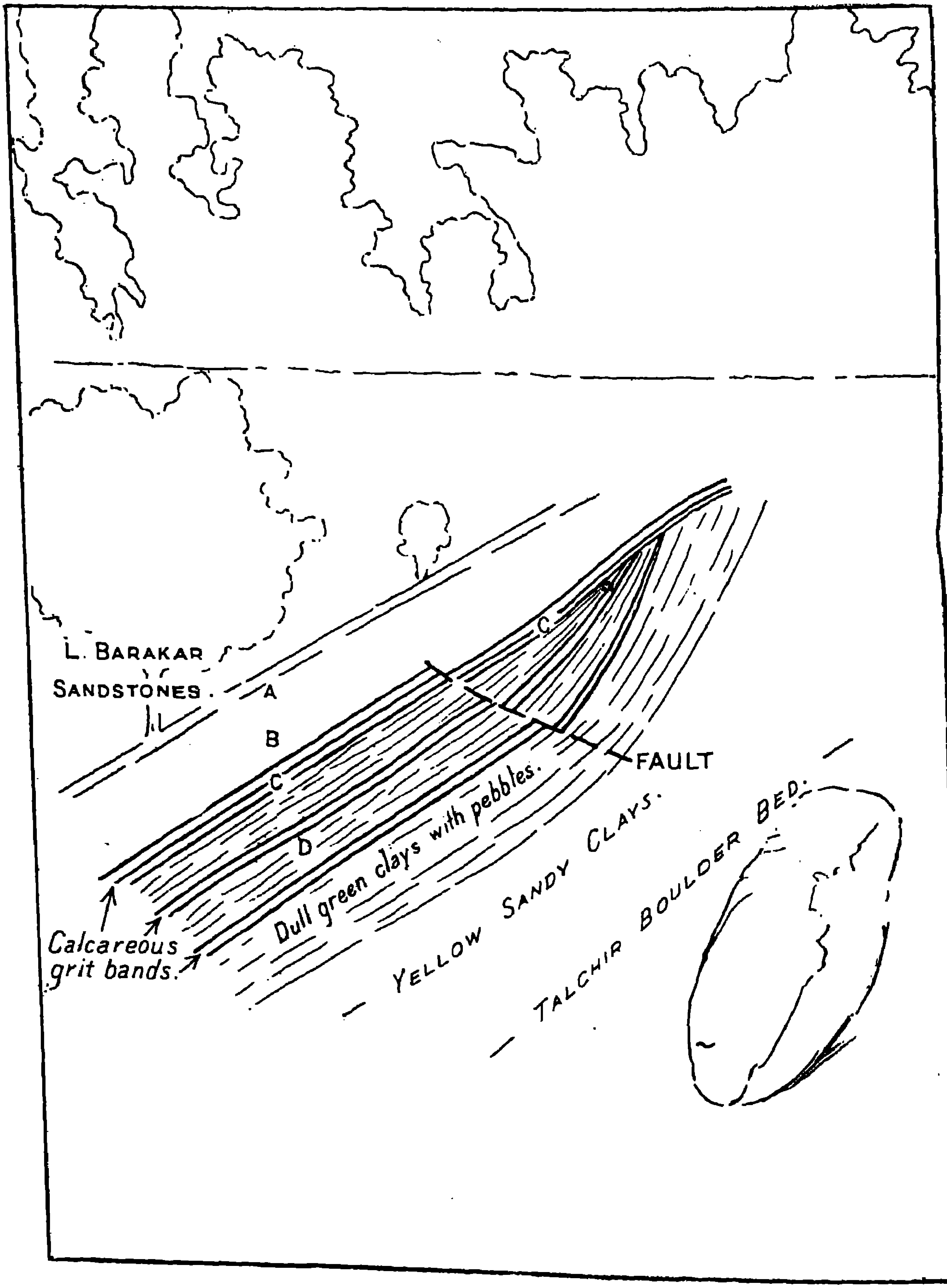
Records, Vol. LX, Pl. 36.



E. T. Talbot, del.

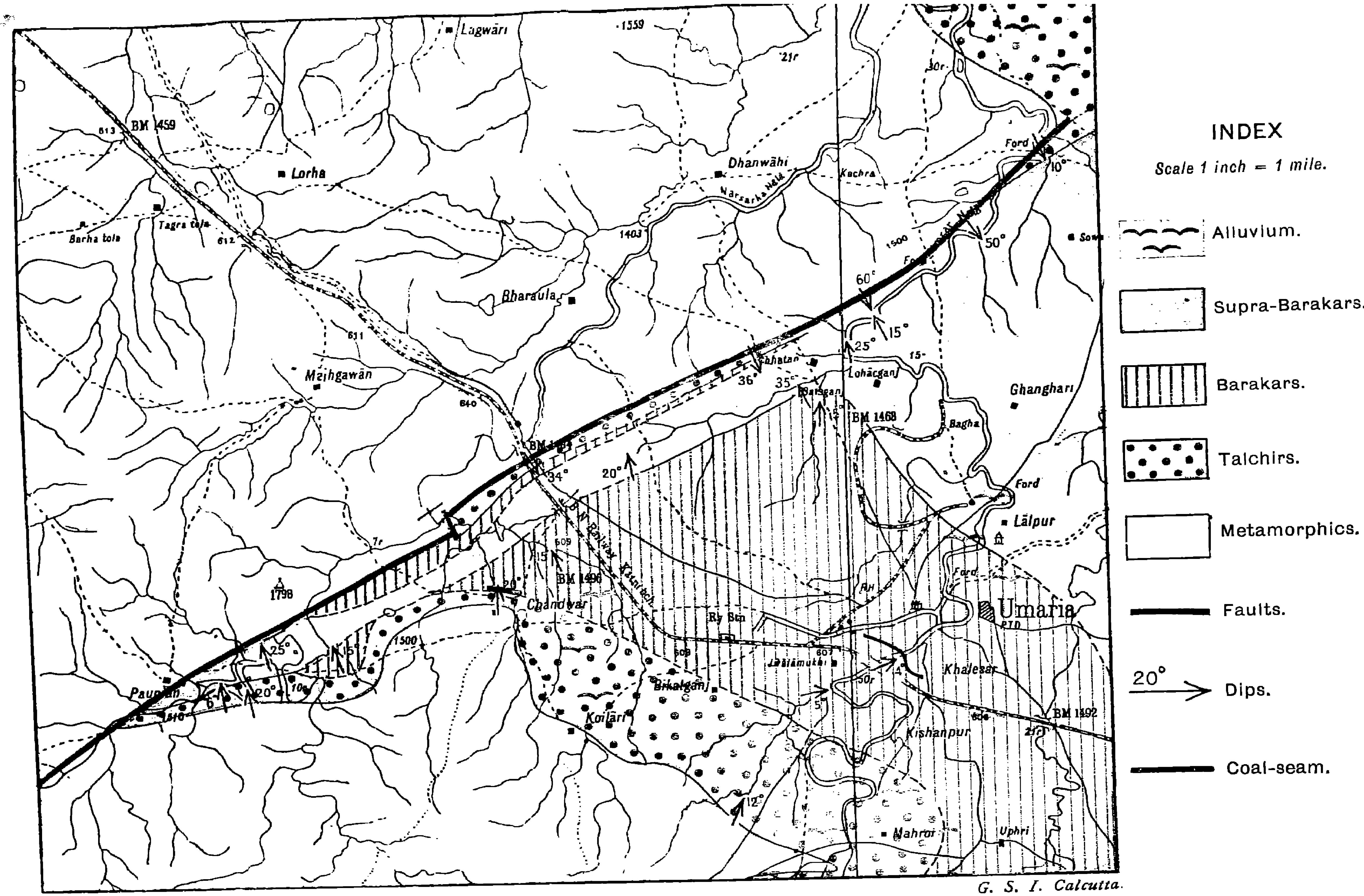
PERMO-CARBONIFEROUS FOSSILS FROM UMARIA.

Key to plate 38.



E. R. Gee, Photo. G. S. I. Calcutta.

NEAR VIEW OF THE MARINE FOSSIL-BEARING BEDS, OF THE WESTERN SIDE OF THE NARSARHA CUTTING.



G. S. I. Calcutta.

GEOLOGICAL MAP OF PART OF THE UMARIA COAL-FIELD.

By E. R. Gee.

samples of the lode or seam at such intervals and over such thicknesses as will enable him both to deduce the average composition of the deposit and to determine which sections of the deposit will repay the cost of working. This, of course, is generally recognised. It is not, perhaps, so generally recognised, however, that very great help is also to be obtained from a chemical study of hand-specimens carefully selected so as to represent the various types of ore, rock, or mineral, building up the mineral deposit.

In the course of my study of the Indian manganese-ore deposits some years ago, I made a careful selection of the various types of ore and had them assayed not only for the constituents usually taken into account in the valuation of manganese-ores, namely, manganese, iron, silica, phosphorus, and moisture, but in addition I was fortunately able to have some of them subjected to complete analysis. Half of each specimen was used for the analysis after the determination of its specific gravity, and the other half was retained for reference. By a comparison of the analysis of a specimen with its appearance, it was possible to work out the quantitative mineral composition of each specimen, and thus to obtain data for an intelligent understanding of the composition of the orebody as a whole.

On visiting a new manganese-ore deposit it is usually found to be composed of some few of the types of ore already analysed, and it is then simple, by forming a rough estimate of the proportions in which these types are present in the ore-body, and by using one's knowledge of the composition of each type, to form a very fair estimate of the quality of the deposit in advance of the receipt of the results of assays of average samples of the ore, which can as a rule come to hand only after one has left the deposit in question.

On account of the valuable results thus obtained, I was lead to apply similar methods to the study of the Korea coalfields in 1913, and of the Bokaro coalfield in 1916-17. As I have now accumulated a considerable number of analyses of hand-specimens of coal from these two areas and as the study of the Korea data led to the discovery of a rough relationship between the specific gravity of a piece of coal and its ash contents, which was confirmed by data for the Bokaro coalfield subsequently obtained, and as a knowledge of this relationship will enable one to determine the ash contents of a piece of coal in the field usually within four units of the correct figure, and often very much closer, merely by a specific gravity

determination with a Walker's balance, it is, I think, desirable to detail my results for the benefit of the mining community[1].

II.—THE COALS OF THE KURASIA COALFIELD, KOREA STATE.

In my paper 'On the Geology and Coal Resources of Korea State, Central Provinces' published in 1914[2], I have given on p. 182 a table of analyses of 7 hand-specimens of coal from various seams (Barakar series) in the Kurasia coalfield in this State. Each specimen was broken into two roughly equal portions and the specific gravity determination was made in each case on the piece of coal that was actually powdered up for analysis, the other piece of each specimen being kept for future reference. The most interesting type thus examined is the bright coal occurring in layers in the banded coal. This bright coal breaks easily into polyhedral fragments with conchoidal fracture surfaces, and has all the appearance of being a colloid substance and the purest type of coal. As will be seen from the analysis of D. 183 below, this bright coal proves to be nearly pure coal with only 0·51 per cent. ash and a specific gravity of 1·30. Assuming that the specific gravity of theoretically pure coal from Kurasia with no ash would be 1·29, I noticed that if this figure were deducted from the specific gravity of each

[1] That the specific gravity of coal increases with the ash percentage is, of course, a well-known fact, and there have, of course, been other researches in which some co-relation between analysis and specific gravity has been noted, at least implicitly, by the publication of tables of analyses of coals with corresponding specific gravity determinations. The following papers may be cited :—

M. L. Nebel. 'Specific Gravity Studies in Coal', University of Illinois, Bull. No. 89 ; abstract in *Colliery Guardian*, CXIII, pp. 33-34, (1917).

M. W. Blyth & L. T. O'Shea, 'The Examination of Coal in Relation to Coal-washing', *Trans. Inst. Min. Eng.*, LVII, p. 267, (1919).

T. Fraser and H. F. Yancey, 'Cleaning Tests of Central Illinois Coal', Tech. Paper 361, Bureau of Mines, Washington, pp. 9-13, (1925).

W. Randall, 'Froth Flotation of Indian Coals', *Rec., Geol. Surv. Ind.*, LVI, p. 223, (1925).

Draper and Evans, quoted by J. Coggin Brown in 'Indian Coal Problems', *Bull. Ind. Industries & Labour*, No. 36, p. 23, (1927).

Such investigations have, however, usually been carried out in relation to problems of coal beneficiation, and the authors have not detected a relationship such as that noticed in this paper. Blyth and O'Shea, indeed, go so far as to write (*l.c.*, p. 269) :—

> "Generally, the specific gravity increases with the ash content, but, as is evident, no definite relation can be established between ash content and specific gravity, as if the increase is due to admixed mineral matter, the resultant specific gravity will depend on the relative specific gravities of the coal substance and mineral matter and on the proportions in which they are mixed."

[2] *Mem. Geol. Surv. Ind.*, XLI, pt. 2.

of the other types of coal, the results multiplied by 100 agreed roughly with the determined ash contents of the specimen. The values for the ash contents that might thus be predicted, as compared with those actually found, are shown below for each of the 7 specimens in question :—

Specific gravity.	Predicted ash contents.	Determined ash contents.
1·30	1	0·51
1·36	7	9·28
1·45	16	16·42
1·52	23	18·54
1·64	35	33·28
1·61	32	34·96
1·47	18	32·06

Except for the 4th and last analyses the figure predicted is in every case within 3 units of the figure obtained by actual determination. But on account of these two discrepancies, especially the last, I refrained from drawing attention to this fact in the memoir in question, as I was on leave in Europe at the time the proofs passed through my hands, and had no opportunity of checking the two apparently anomalous analyses. The work has since been repeated on a portion of the duplicate material in each case and the results indicate that the analytical and the specific gravity figures of these two coals as printed in the memoir cited have been interchanged. The following table repeats here the analyses of the 7 Kurasia coals referred to above, except that the revised figures are given for the specimens K.4 and 'Gorghela N.' respectively. The analyses are here arranged in order of increasing ash contents. It will be noticed that this is almost coincident with the order of increasing specific gravity. In column 9 is shown the figure obtained by subtracting from the specific gravity the ash contents divided by 100, from which, excluding the figures for the specimens from Gorghela N., one obtains an average of 1·28, which may be used as the datum line for ash-free coal from this field. Using this datum line the figures given in column 10 show the ash contents as predicted

from the specific gravity figures. Column 11 shows the error in the prediction in each case, the maximum error except for specimen G. N., being only 3 units. The only case in which prediction of ash contents from a specific gravity determination would have led to serious error is the specimen from Gorghela Nala, for which the ash contents thus predicted would have been 24 per cent. against nearly 31 per cent., an error as it happens in the right direction, as it would have led to the sampling of the Gorghela Nala seam instead of its neglect.

TABLE 1.—*Analyses, specific gravities and descriptions of hand-*

No. of specimen.	Rock register number.	Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash as determined.	Specific gravity (G).	G— $\frac{ash}{100}$
1	2	3	4	5	6	7	8	9
D. 183 . .	26·669	Daukihuri .	9·80	29·18	60·51	0·51	1·30	1·29
D. 164 . .	26·649	Kachhan Kundi	4·66	33·64	52·42	9·28	1·36	1·27
K. 3 . .	27·433	Karar Khoh .	6·16	27·76	49·66	16·42	1·45	1·29
K. 4 . .	27·434	Do. .	7·10	30·26	45·37	16·77	1·435	1·27
G. N. . .	27·435	Gorghela Nala	3·47	29·38	36·55	30·60	1·52	1·21
D. 154 . .	26·639	Karar Khoh .	4·10	19·10	43·52	33·28	1·64	1·31
K. 2 . .	27·432	Do. .	3·80	22·28	38·96	34·96	1·61	1·26